Feb. 13, 1923. 1,444,778

L. S. CHADWICK

INTERNAL COMBUSTION ENGINE

Filed Oct. 28, 1916 5 sheets-sheet 1

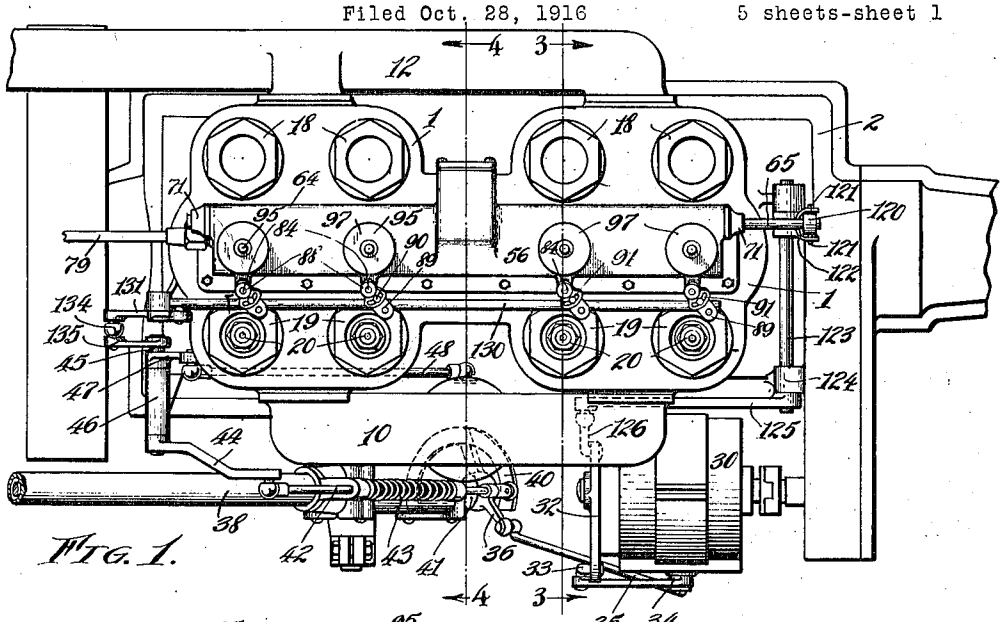


FIG. 1.

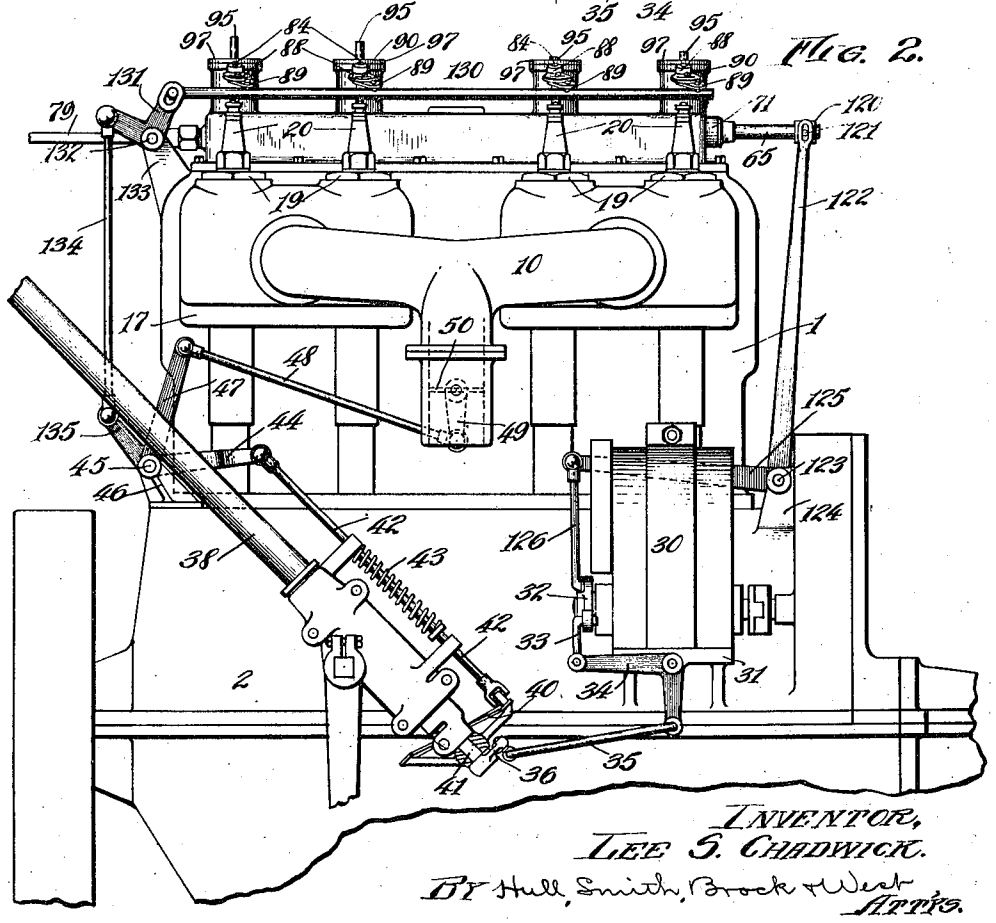


FIG. 2.

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Filed Oct. 28, 1916 5 sheets-sheet 2

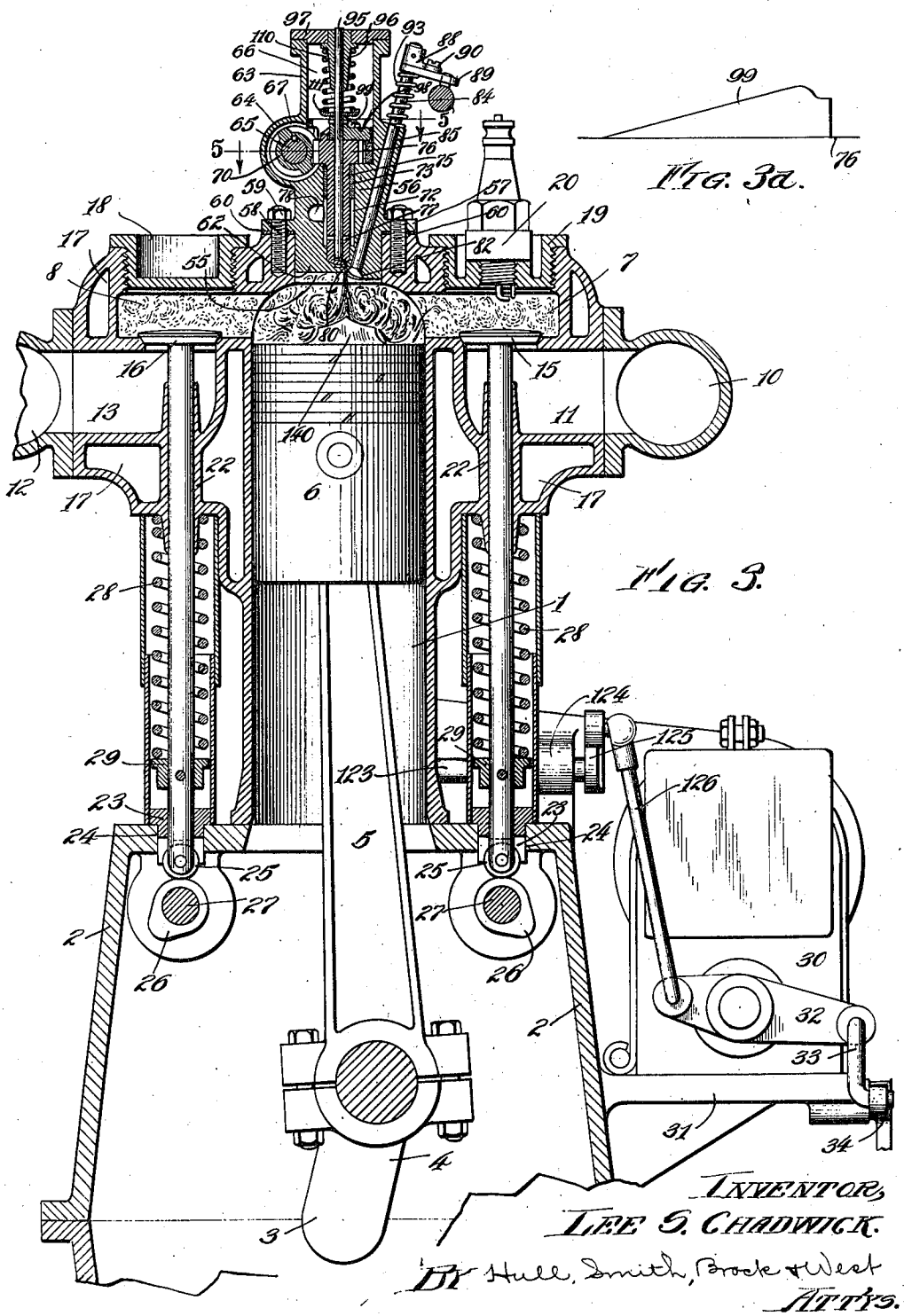


FIG. 3a.

FIG. 3.

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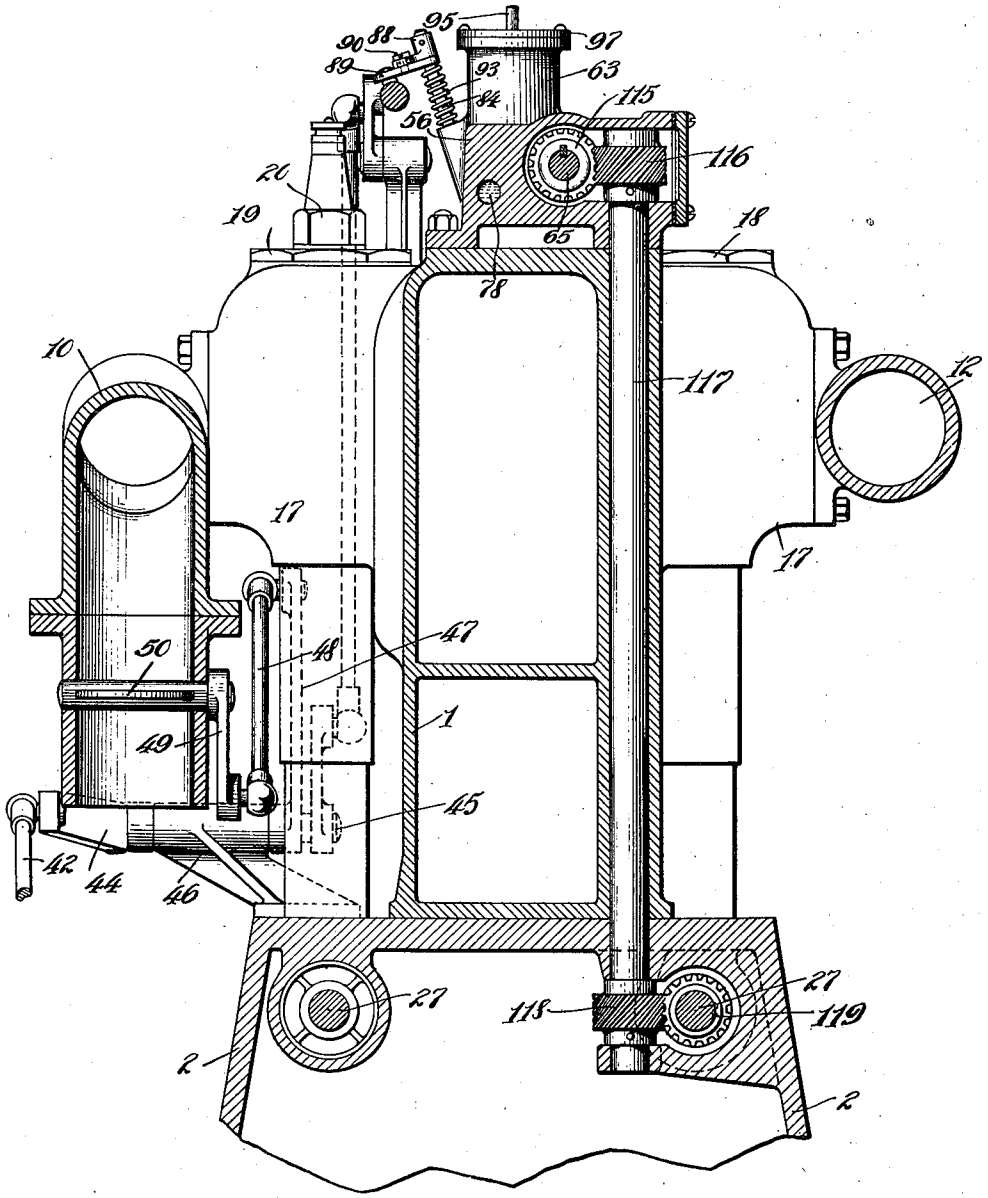


FIG. 4.

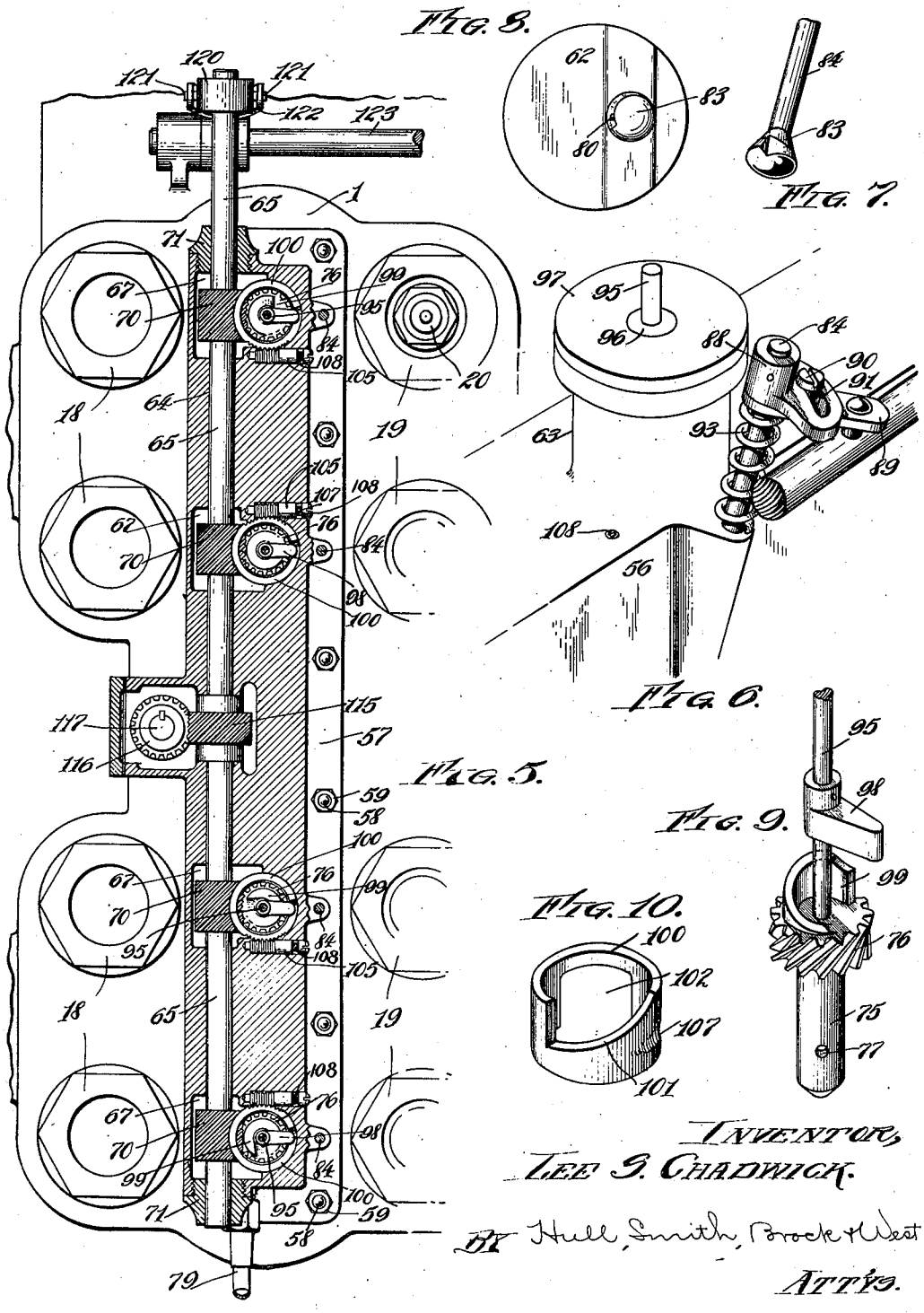
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INTERNAL COMBUSTION ENGINE

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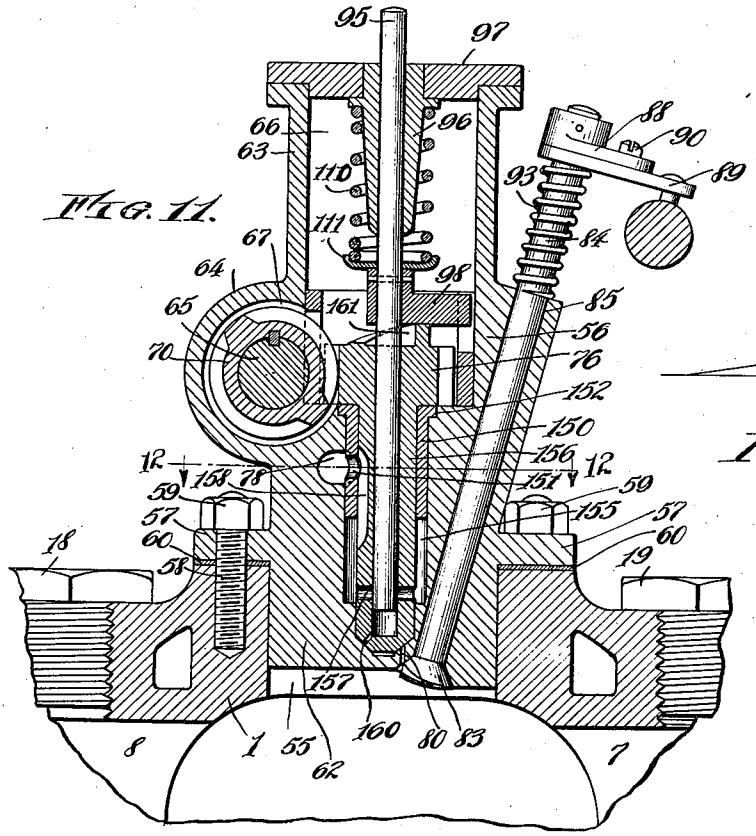
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L. S. CHADWICK

INTERNAL COMBUSTION ENGINE

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FIG. 11.



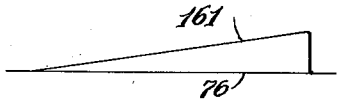
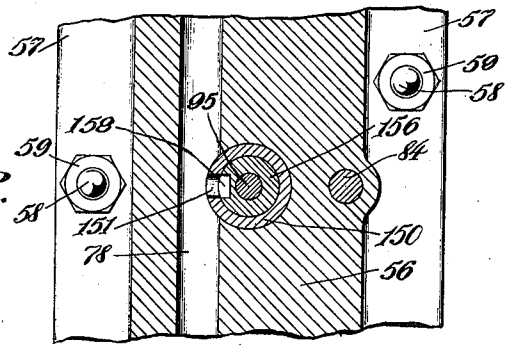


FIG. 11a.

FIG. 12.



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Patented Feb. 13, 1923. 1,444,778

UNITED STATES PATENT OFFICE.

LEE S. CHADWICK, OF EAST CLEVELAND, OHIO.

INTERNAL-COMBUSTION ENGINE.

Application filed October 28, 1916. Serial No. 128,167.

To all whom it may concern:

Be it known that I, LEE S. CHADWICK, a citizen of the United States, residing at East Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Internal-Combustion Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings.

This invention relates to internal combustion engines, and particularly to such as are used in automobiles; the invention having to do more especially with a fuel injecting mechanism for adapting engines of this character to the use of kerosene or lower grades of petroleum.

By means of the fuel injecting mechanism of my invention, the lower grades of fuel oils may be injected into the cylinder of a gas engine when a charge of air is compressed therein to about the degrees usual in automobile engines and thoroughly atomized and mixed with the air to produce a vapor which is calculated to be as highly explosive as the vapors obtained from gasoline through the use of the usual carburetors.

The invention has for its main object the production of a fuel injecting mechanism for engines of the general type heretofore requiring the use of a highly volatile liquid fuel, such as gasoline, as their propelling medium, and by the employement of which mechanism the engine is adapted to the use of heavier fuel, such as kerosene, or oils of even lower specific gravity.

A further object of the invention is the production of a fuel injecting mechanism by means of which a heavy fuel oil such as kerosene and lower grades of petroleum, is thoroughly atomized when injected into the cylinder of an explosive engine containing a charge of compressed air. Another object is the incorporation of a suitable deflector against which the charge of fuel may be projected and further broken up for a more thorough intermingling with the air.

Other objects comprehended by my invention are the provision of means for regulating, respectively, the time and quantity of the fuel injection simultaneously with and in proper relation to the spark control mechanism and the main throttle of the engine; to provide means of adjustment for injecting mechanism of each of the cylinders of a multicyclinder engine whereby the timing and quantity of the injection of each may be respectively regulated independently of each other and the injecting mechanisms of the other cylinders; to provide means for preventing the compression within the engine cylinder from being communicated to the fuel chambers of the injecting mechanism; and to provide a comparatively simple and highly efficient mechanism through which the foregoing objects may be attained.

In the accompanying drawings forming a part hereof, and to which I will now refer, I have shown a construction wherein the foregoing objects and others which will become apparent as this description proceeds are attained.

Fig. 1 is a plan view and Fig. 2 a side elevation of an engine embodying my invention; Fig. 3 is a transverse section of the line 3—3 of Fig. 1, the views being taken as looking in the direction of the arrows; Fig. 3ª is a development of a plunger operating cam used in the form of my invention illustrated in Figs. 1 to 10; Fig. 4 is a section on the line 4—4 of Fig. 1; Fig. 5 is a fragmentary plan view of the engine, the fuel injecting mechanism being shown in horizontal section substantially on the staggered line 5—5 of Fig. 3; Figs. 6 and 7 are details, in perspective, of the valve for controlling the amount of the injection; Fig. 8 is a bottom plan view of the valve shown in Fig. 7, and of the member wherein it has its seat; Fig. 9 is a perspective view of the timing valve element, and shows the injector plunger associated therewith; Fig. 10 is a similar view of a recovering cam for the plunger; Fig. 11 is a sectional view of a modified form of my injecting mechanism; Fig. 11ª is a development of the plunger operating cam employed therein; and Fig. 12 is a section on the line 12—12 of Fig. 11.

The cylinder casing of the engine is represented at 1 as surmounting the crank case 2 substantially central within which is supported the crank shaft 3, the cranks 4 whereof are connected, through the pitmen 5, with the pistons 6. The engine wherein I have elected to show my invention incorporated is of the so called T head style, each cylinder having an offset 7 on one side, and an offset 8 on the other, the former having communication with the inlet manifold 10, through a port 11, and the latter with the outlet manifold 12, through a port 13. An inlet valve

15 of the poppet variety controls the inlet of air from the port 11 to the offset 7, and an outlet valve 16 of a similar style controls the outlet of burnt gases from the offset 8 to the port 13. The upper portion of the cylinder of the engine is surrounded by the usual water jacket 17, and an opening through the head of the cylinder above the exhaust valve 16 is adapted to be closed by a plug 18, and a plug 19, which closes a corresponding opening on the opposite side of the cylinder head above the inlet valve 15 carries a spark plug 20. The stems of the valves 15 and 16 are guided within sleeves 22, shown as cast integral with the cylinder casing and the lower ends of the stems, where they project into the crank case through bushings 23 contained within openings 24, are provided with rollers 25, for cooperation with cams 26 carried by the cam shafts 27. All of this is substantially in accordance with the usual construction of engines of this class, and it will be understood, furthermore, that the cam shafts are driven through the usual train of gearing from the crank shaft 3. The valves are normally held against their seats by springs 28, compressed between collars 29 that are pinned to their stems, and opposed portion of the engine casing.

A magneto 30 is shown as supported upon a shelf 31 which projects from the right hand side of the crank case (looking forward), and the timing lever 32 thereof is shown as connected, through link 33, bell crank 34, and link 35, with a crank arm 36 secured to the lower end of a spindle (not shown) which extends upward through the steering column 38. This also is in accordance with the usual practice, as is the employment of a cam 40, carried by a sleeve 41, extending upward through the steering column, for elevating the rod 42, against the tension of a spring 43, to rock, through an arm 44, a shaft 45 wherewith the arm is connected, and which is journaled in a bracket 46 secured to a corner of the crank case. A second arm 47, which is secured to the shaft 45 has its free end connected through a link 48 with the operating arm 49 of an air throttle 50 which is shown in the form of a "butterfly" valve that is pivoted transversely the intake end of the air inlet manifold 10.

A flat finished surface extends longitudinally of the top of the cylinders, and an opening 55 is formed within the top of each cylinder. The body member 56 of my injecting mechanism extends substantially the full length of the top of the cylinders and is shown as provided with a flange 57 having apertures for the reception of studs 58 which are carried by the cylinders and which receive, above the flange 57, nuts 59, a gasket 60 of suitable material being interposed between the flange and the pad of the engine cylinder whereon the mechanism rests. A projection 62 of the body member occupies each of the openings 55, and in vertical alignment with these projections is a cylindrical extension 63. Extending along one side of the body member is a semi-cylindrical portion 64 that has a substantially concentric bore within which is journaled a shaft 65. A chamber 66 is formed in each of the extensions 63 and extends downward into the body member slightly below the horizontal center of the semi-cylindrical portion 64, and in the region of each of these chambers, the said portion 64 is cored out to produce a lateral extension 67 of such chamber wherein an angle gear 70 reposes and is secured to the shaft 65. At both ends of the body member, the portion 64 is provided with bushings 71 wherein the ends of the shaft 65 are journaled. A bore 72 extends downward from each chamber 66, and at its lower end is reduced in diameter. A bushing 73 is fitted into the upper end of the bore 72, and within this bushing, and the lower reduced end of the bore 72, is journaled the tubular timing valve element 75. This valve element is provided with an angle gear 76 at its upper end which meshes with one of the former angle gear 65, and it has a central longitudinal bore or fuel well extending to within a short distance of its lower end. The bore or fuel well of the timing valve element is adapted to communicate, through openings 77, with what I shall term a fuel chamber that is formed by the lower portion of the bore 72 beneath the bushing 73. A fuel supply passageway 78 extends longitudinally through the body member 56 and opens into the side of each of the fuel chambers, and fuel is supplied to the passageway through a tube 79 which has connection with said passageway at one end. A port of comparatively small diameter leads diagonally through the end wall of the valve element 75 and is adapted to register, when said element is in a given angular position, with a fuel injection port 80 of preferably yet smaller diameter, which extends through the end of the projection 62 of the body member the same opening through the inclined wall of the seat 82 of a tapered valve 83 the stem 84 whereof extends upward through an inclined bore 85, formed in the side of the body member. The stem 84 projects some distance above the body member, and its upper end has pinned to it the hub of a segment 88 beneath which the inner end of an arm 89 is loosely mounted upon the stem, the arm having threaded into it a screw 90 which extends freely through an arcuate slot 91 in the segment 88. By this means, the segment, and consequently the stem and valve 83 may be adjusted angularly with respect to the arm 89, the screw 90 serving to hold the parts firmly together

when screwed down tight. The valve 83 is held against its seat by a compression spring 93 which surrounds the exposed portion of the stem 84 and is confined between the arm 89 and the opposed portion of the body member.

The construction just described is clearly shown in perspective in Fig. 6; and from Figs. 7 and 8 it will be seen that one side of the valve 83 is cut away gradually inward from its periphery to a depth sufficiently to uncover the port 80, when the deepest part of such cutaway portion is adjacent the port. Therefore, the effective area of the port may be altered by turning the valve to cover the port more or less.

The lower portion of a rod or plunger 95 occupies the bore or fuel well of the valve element 73, while its upper portion is guided within a tubular extension 96 of the cap 97 which closes the upper end of the chamber 66. Just above the gear 76 which constitutes the upper end of the valve element 75 the plunger 95 has pinned to it an abutment member 98 that extends out over a cam 99 carried by and preferably formed integral with the gear 76. It will be observed, particularly from Fig. 9, that the cam gradually rises from the plane of the gear upward until it reaches a high point at substantially 180° from its start, and then recedes somewhat until it terminates in an abrupt drop to the elevation of its beginning.

Surrounding the gear and resting upon the bottom of the chamber 66 is a cylindrical member which I shall term a recovering element 100. The recovering element is shown in perspective in Fig. 10, and at one side is cut abruptly downward equal to or below the elevation of the upper surface of the gear 76 (when the parts are assembled as shown in Fig. 3), and from this depth the edge of the cut away portion rises gradually to the original height of the member. This forms a cam portion 101 which may be referred to as the recovering cam. Opposite the cam, the member is cut away at 102 to permit the gear 70 to project through said member and mesh with the gear 76. The recovering element may be adjusted angularly within the chamber, for a purpose later to be described, by means of a screw 105 which is contained within a bore in the body member. the inner end of the bore and screw being reduced in diameter to provide a suitable bearing for the inner end of the screw. The bore which is occupied by the screw opens into the side of the chamber 66 so that the threads of the screw may mesh with threads 107, formed in the side of the recovering element. A groove about the screw near its outer end received the end of a retaining screw or pin 108 which may be inserted downward from the top and through the body member into the groove. By reason of this construction, the recovering element may be rotated slightly within the chamber by the operation of the screw. The abutment member 98 extends out over the cam 99 and into the notch of the recovering element, the recovering element rising a material distance above the cam so that the latter is unable to elevate the abutment member above the top of the former. A heavy spring 110 is compressed between a dished washer 111 that surrounds the plunger 95 and bears upon the hub of the abutment member 98, and the opposed portion of the cover 97, and acts to depress the plunger. In the normal running of the engine, the gear 76 is driven in a direction to cause the lower end of the cam 99 to engage beneath the abutment 98 and elevate the abutment together with the plunger gradually as the cam continues to rotate until the high point of the cam is reached. It will be remembered that the abutment member 98 is pinned to the plunger, and it may be explained that both are free to rotate but for the engagement of the end of the abutment member with the vertical wall of the notch in the recovering element 100, it being noted that the cam 99 is inclined in the opposite direction to the recovering cam 101. Consequently, the abutment member 98, under normal conditions, is reciprocated along the vertical side of the notch of the recovering element as the cam continues to rotate; and should the operation of the engine be reversed by reason of "back firing" (an action well known to those familiar with this subject), the abrupt or vertical end of the cam 99 would engage the abutment 98 and push it up the recovering cam 101 until said cam elevates it above the plane of the cam 99. Therefore, no harm can result from the backward rotation of the cam 99.

From the description thus far it will be seen that as the shaft 65 is rotated (by means hereinafter to be described) the gears 76 of the valve elements 75, and consequently the cams 99, will be continuously rotated to effect the reciprocation of the plunger 95 and also to bring the ports 79 of the valve elements into registration with the fuel injection ports 80. The parts are so designed and proportioned that the ports 79 will register with the ports 80 as nearly as practicable to the instant the abutments 98 drop from the vertical ends of the cams 99, in order that the charge of fuel oil which has gravitated into the bottom of the bore or fuel well of the valve element 75 will be forced through the ports 79 and 80 by the action of the spring 110. This being a comparatively stiff spring and the area of the plunger relatively small, the fuel will be injected into the cylinder of the engine at an extremely high pressure and correspondingly high velocity. It will be seen from

this that no difficulty will be experienced in injecting the charge into the cylinder, notwithstanding the fact that the air within the cylinder is compressed to the usual, or even somewhat greater than the usual degree. With the conditions just set forth in mind, the purpose of the drop which occurs beyond the high point of the cam 99 will be readily understood. Let it be remembered that the high point of the cam elevates the plunger 99 a sufficient distance to uncover the fuel inlet openings 77. It will also be recalled that by the time the end of the cam rides from beneath the abutment to allow the descent of the plunger, the ports 79 and 80 have come into register. Therefore, between the time the abutment passes over the high point of the cam and the time it drops from the end of the cam, there is an interval when the plunger is allowed to recede sufficiently to cover the fuel inlet openings 77. This is done to prevent the fuel within the fuel well or bore of the valve element 75 from being forced back into the fuel chamber or passageway by the compressed charge within the cylinder of the engine should the ports 79 and 80 come into register slightly before the release of the plunger. In other words, it takes care of a situation which would otherwise have to be taken care of by so fine an adjustment or proportioning of parts that it might prove impractical.

At about its longitudinal center, the shaft 65 has secured to it an angle gear 115 which meshes with a similar gear 116 that is pinned to the upper end of a vertical shaft 117 which extends downward through a suitable bore in the engine casing and into the crank case in juxtaposition to one of the cam shafts 27. Here the shaft 117 has secured to it an angle gear 118 which is driven by a similar gear 119 that is secured to the cam shaft. Thus a convenient drive is provided for the shaft 65.

The gear 115 is splined to the shaft 65 so that the shaft is capable of a slight longitudinal movement without affecting the gear and the chambers which contain the gears 70 are enough longer than the gears to allow them to shift lengthwise of the chamber. A collar 120 is secured to the forward end of the shaft 65 and opposed trunnions 121 thereof extend through slots in the branches of the forked upper end of an arm 122 that is secured to a shaft 123, journaled within brackets 124 on the crank case of the engine. As will appear clearly from Fig. 1, the shaft 123 projects beyond the right hand side of the cylinders of the engine where it has secured to it an arm 125 that has its free end connected by a link 126 to an extension of the timer 32 of the magneto 30.

By reason of this connection between the timer and the shaft 65, the shaft will be reciprocated when the timer is adjusted, thereby to shift the gears 70 bodily endwise and change the angular position of the valve elements 75 within their respective bores. This will result in an advance or in a retardation of the registering of the ports 79 and 80 (according to the direction of movement of the shaft) which will be in unison with the corresponding adjustments of the "spark" for it will be understood that the injection and ignition of the charge must be substantially simultaneous, or at least, bear a constant relation.

I have already explained how the quantity of the injection may be altered by the adjustment of the valve 80 through the arms 89. The outer ends of the arms 89 are pivoted to a link 130 which has its rear end similarly connected to one arm of a bell crank 131 that is fulcrumed upon a stud 132, carried by a bracket 133 which projects from the cylinder casing of the engine. The opposite arm of the bell crank is connected, through a link 134, with an arm 135, fastened to the shaft 45 previously referred to in connection with the throttle adjustment. Therefore, as the throttle 50 is adjusted to vary the quantity of air admitted to the cylinders, the valves 80 are also adjusted to control the amount of fuel injected into the cylinder.

Although it is not considered essential to a thorough atomizing of the fuel, a deflector 140, may, if desired, be located upon the upper end of each piston against which the charge is projected, the deflector being of such shape as to accomplish a thorough distribution of the charge throughout the head of the cylinder and the offsets 7 and 8 thereof, and serving also to further break up the atoms of fuel.

I have already explained one way of preventing the fuel within the fuel well of the injecting mechanism from being expelled by the compressed charge of air within the cylinder, should the well and cylinder be thrown into communication before the plunger is forced downward to inject the charge; and I will now describe a modification of my invention, illustrated in Figs. 11, 11ª and 12, wherein the same end is attained in a different but very satisfactory way.

The majority of the parts of the mechanism shown in Fig. 11 are identical with the corresponding parts of the form previously described, wherefore I will refer to them by the use of the same reference characters, the only parts altered being the valve element, the cam carried thereby, and the bushing within which said element rotates.

In the present modification of my invention the bushing contained within the reduced lower end of the chamber 66 is shown

at 150, the same being provided with an aperture 151 which opens into the fuel passageway 78 of the body member. The upper end of the bushing is shown as provided with a flange 152 which is contained within a rabbetted seat in the body member, and the bushing may be held from turning within the chamber by any suitable means, The bushing terminates a sufficient distance from the lower end of the chamber to provide a fuel reservoir 155 that is in constant communication with the bore or fuel well of the valve element 156, through the inlet openings 157. A groove 158, along one side of the valve element, is long enough to establish communication between the fuel passageway 78 and the reservoir 155 when the groove is in register with the aperture 151 of the bushing. The outlet port of the valve element is shown at 160, and it will be observed that this port, the fuel injection port 80, of the body member 56, the groove 158, and the aperture 151 are so arranged with respect to each other that the ports 160 and 80 can not register except when the groove 150 is out of register with the aperture 151. Therefore, the communication of a compressed charge within the cylinder to the fuel supply passageway 78 is rendered impossible. This arrangement obviates the need of closing the inlet ports of the fuel well by an initial and partial descent of the plunger, and for this reason the cam 161 of the valve element, which retracts the plunger, may gradually and continually rise from beginning to end, as clearly revealed by the diagrammatic development of the cam shown in Fig. 11a.

Attention is called to the fact that the valve for varying the capacity or effective area of the fuel injection port is located at the outlet end of the port or within the engine cylinder. This is of considerable importance from a practical standpoint for it presents fuel being left in the port to "poison" or over-enrich a subsequent charge. The presence of a superfluous quantity of fuel in the cylinder which would result in the absence of the foregoing arrangement would be particularly noticeable when endeavoring to change the speed of the engine from high to low.

While I have illustrated the fuel injecting mechanism of my invention as embodied within an element separate from and adapted for attachment to the cylinders of an engine, it will be understood that the same might constitute a more integral part of the engine, the portion which I have referred to as the body member of the mechanism in such a case being cast with the engine cylinder casing. Also in the annexed claims where I have defined the mechanism as a part of an engine, such claims will be understood to cover the combination recited thereby either as an integral part of the engine structure or an attachment which may be applied to the engine.

Having thus described my invention, what I claim is:—

1. An internal combustion engine comprising a cylinder casing having a fuel injection port and a fuel well wherewith the cylinder is adapted to communicate through said port, there being a fuel inlet for the well that is spaced from the injection port, a plunger reciprocable within the well, means tending to impel the plunger in a direction to force fuel from the well through the injection port and mechanism for retracting the plunger beyond the fuel inlet and then returning it sufficiently to close the inlet during the compression stroke of the engine piston, said mechanism thereafter acting to release the plunger to force fuel thereby to submit it to the action of the aforesaid impelling means.

2. An internal combustion engine comprising a cylinder casing having a chamber and a fuel injection port through which said chamber communicates with the interior of the cylinder, a valve element movable within the chamber and having a fuel well and a port leading therefrom, means for moving the valve element to bring its port into register with the fuel injection port, a plunger reciprocable within the well of the valve element, said valve element having a fuel inlet that is spaced from its aforesaid port, means tending to impel the plunger in a direction to force fuel through the said ports when the ports are in register, and means for retracting the plunger beyond the inlet thereby to supply the well with fuel and for returning it sufficiently to close said inlet, said means functioning to release the plunger when the ports are in register.

3. An internal combustion engine comprising a cylinder casing having a chamber and a fuel injection port through which said chamber communicates with the interior of the cylinder, a valve element movable within the chamber and having a fuel well and a port leading therefrom, means for moving the valve element to bring its port into register with the fuel injection port, a plunger reciprocable within the well of the valve element, said valve element having a fuel inlet that is spaced from its aforesaid port, and means for retracting the plunger beyond the inlet thereby to supply the well with fuel and for returning it sufficiently to close said inlet, said means thereafter acting to impel the plunger in a direction to force the fuel from the well through the aforesaid ports when the ports are in register.

4. An internal combustion engine comprising a cylinder casing having a chamber, a valve element rotatable within said cham-

ber, the chamber having a cylindrical portion within which a correspondingly shaped portion of the valve element bears and rotates, the cylinder casing having a port which leads from such portion of the chamber to the interior of the cylinder, the valve element having a bore and a port leading therefrom through its wall for register with the aforesaid port, means for rotating the valve element, a plunger reciprocable within the bore of the valve element, means tending to impel the plunger in a direction to force fuel from the bore through the aforesaid ports when the ports are in register, a cam carried by the valve element, an abutment carried by the plunger wherewith the cam is adapted to engage, and means for retaining the plunger against rotation in the direction of rotation of the cam, said cam being so shaped as to retract the plunger when the aforesaid ports are out of register and to release the same when the ports are in register, the valve element having a fuel inlet port that is adapted to be uncovered by the plunger when the same is retracted.

5. An internal combustion engine comprising a cylinder casing having a chamber, a valve element rotatable within said chamber, said valve element having a bore and a port, and the cylinder casing having a fuel injection port wherewith the former port is adapted to register, the valve element and chamber having engaging bearing surfaces in the zone of the ports whereby the fuel injection port is maintained closed except when in register with the port of the valve element, the valve element having also a fuel inlet opening that is spaced from its aforesaid port, the cylinder casing having a fuel passageway through which fuel may be conducted to said fuel inlet opening, a plunger reciprocable within the bore of the valve element, means tending to impel the plunger in a direction to force fuel from the bore through the ports when said ports are in register, a cam carried by the valve element, an abutment carried by the plunger wherewith said cam is adapted to engage, means for retaining the plunger against rotation in the normal direction of movement of the cam, said means acting to retract the plunger upon a reverse movement of the cam, and operative connections between the valve element and the crank shaft of the engine whereby the former is driven in a given time and direction relation thereto.

6. An internal combustion engine comprising a cylinder casing having a chamber, a valve element rotatable within said chamber, said valve element having a bore and a port, and the cylinder casing having a fuel injection port wherewith the former port is adapted to register, the valve element and chamber having engaging bearing surfaces in the zone of the port whereby the fuel injection port is maintained closed except when in register with the port of the valve element, the valve element having also a fuel inlet opening that is spaced from its aforesaid port, the cylinder casing having a fuel passageway through which fuel may be conducted to said fuel inlet opening, a plunger reciprocable within the bore of the valve element, means tending to impel the plunger in a direction to force fuel from the bore through the ports when said ports are in register, a cam carried by the valve element, an abutment carried by the plunger wherewith said cam is adapted to engage, means for retaining the plunger against rotation in the normal direction of movement of the cam, said means acting to retract the plunger upon a reverse movement of the cam, operative connections between the valve element and the crank shaft of the engine whereby the same is driven in a given time and direction relation thereto, and means whereby the valve element may be adjusted angularly of the chamber.

7. An internal combustion engine comprising a cylinder casing having a chamber and a port through which said chamber communicates with the interior of the cylinder, a valve element rotatable within said chamber and having a bore and a port leading therefrom through the wall of the element, said port being adapted to register with the former port, the valve element and chamber having bearing surfaces in the region of the ports whereby the former port is retained closed except when in register with the latter port, the valve element having a fuel inlet opening spaced from its port, and the cylinder casing a fuel passageway for conveying fuel to said inlet opening, a plunger reciprocable within the bore of the valve element, means tending to impel the plunger in a direction to force fuel from the bore of the element through the aforesaid ports when the ports are in register, a cam carried by the valve element, an abutment carried by the plunger for cooperation with said cam, the cam being shaped to retract said plunger when it engages the aforesaid abutment a sufficient distance to uncover the inlet opening of the valve element and then return the same to cover such opening, subsequently withdrawing from the abutment to release the plunger, means engaged by the abutment for preventing the rotation of the plunger in the direction of normal movement of the cam and acting to retract said plunger if rotated by the cam when moving in the opposite direction, a device for adjusting the aforesaid means angularly with respect to the plunger whereby the time of its release by the cam may be varied, operative connections between the valve ele-

ment and the crank shaft of the engine whereby the former may be driven at a given time and direction relation thereto.

8. An internal combustion engine comprising a cylinder casing having a chamber and a port through which said chamber communicates with the interior of the cylinder, a valve element rotatable within said chamber and having a bore and a port leading therefrom through the wall of the element, said port being adapted to register with the former port, the valve element and chamber having bearing surfaces in the zone of the ports whereby the former port is retained closed except when in register with the latter port, the valve element having a fuel inlet opening spaced from its port, and the cylinder casing a fuel passageway for conveying fuel to said inlet opening, a plunger reciprocable within the bore of the valve element, means tending to impel the plunger in a direction to force fuel from the bore through the aforesaid ports when they are in register, a cam carried by the valve element, an abutment carried by the plunger for cooperation with said cam, the cam being shaped to retract said plunger when it engages the aforesaid abutment a sufficient distance to uncover the inlet opening of the valve element and then return the same to cover such opening, subsequently withdrawing from the abutment to release the plunger, means engaged by the abutment for preventing the rotation of the plunger in the direction of normal movement of the cam and acting to retract said plunger if rotated by the cam when moving in the opposite direction, a device for adjusting the aforesaid means angularly with respect to the plunger whereby the time of its release by the cam may be varied, a shaft slidably supported adjacent the valve element, an angle gear secured thereto, the valve element having a corresponding gear which meshes with the former gear, driving connections between said shaft and the crank shaft of the engine whereby the former is driven at a given time and direction relation thereto, and means whereby the shaft may be adjusted longitudinally and the valve element angularly within the chamber to vary the time of registering of the aforesaid ports.

9. In an internal combustion engine, the combination of a fuel injecting mechanism comprising a body having a port through which fuel may be injected into the cylinder of the engine, said body having a valve seat through which the port opens into the cylinder, rotary valve for cooperation with said seat, said valve being cut away on one side gradually inward from its periphery to an extent sufficient to uncover the aforesaid port, and means whereby the valve may be rotated to alter the effective area of the port.

10. In an internal combustion engine, the combination of a fuel injecting mechanism comprising a body having a port through which fuel may be injected into the cylinder of the engine, said body having a valve seat through which the port opens into the cylinder, a rotary valve for cooperation with said seat, said valve being cut away on one side gradually inward from its periphery to an extent sufficient to uncover the aforesaid port, the body portion having a bore in axial alignment with the valve seat and the valve a stem extending outward through said bore and beyond the outer end thereof, and a device having operative connection with the outer end of the stem for rotating the valve.

11. A fuel injecting mechanism for internal combustion engines comprising a body having a port through which fuel may be injected into the cylinder of the engine, said body having a valve seat through which the port opens into the cylinder, a rotary valve for cooperation with said seat, said valve being cut away on one side gradually inward from its periphery to an extent sufficient to uncover the aforesaid port, a spring for retaining the valve against its seat, and means for rotating the valve, and further means situated exteriorly of the cylinder casing for adjusting the aforesaid means.

12. In an internal combustion engine, the combination of a cylinder casing having a fuel injection port opening directly into the cylinder, a member situated within the cylinder in constant contact with the wall through which the port opens and adapted to overlap the port to a greater or less extent, according to the adjustment of said member, for varying the capacity of the port thereby to regulate the quantity of injected fuel, and means situated exteriorly of the cylinder for adjusting the said member.

13. An internal combustion engine comprising a plurality of cylinders having each a fuel injection port, means located at the outlet end of each port for varying the capacity thereof, connections between the means of the various ports whereby said means may be adjusted in unison, and mechanism for adjusting the means of each port independently of the means of the others.

14. An internal combustion engine comprising a cylinder casing having a fuel injection port, there being a well in communication with said port, a plunger within said well, a spring for impelling said plunger in a direction to create a pressure within the well thereby to force fuel through the aforesaid port into the engine cylinder, a cam operating normally in a given direction to retract said plunger against the tension of

the aforesaid spring and to instantaneously release the same, and means for retracting the plunger should the cam move in the opposite direction.

15. An internal combustion engine comprising a cylinder casing having a fuel injection port, there being a well in communication with said port, a plunger within said well, a spring for impelling the plunger in a direction to create a pressure within the well thereby to force fuel through the aforesaid port into the engine cylinder, a cam normally movable in a given direction to retract said plunger against the tension of the aforesaid spring and instantaneously release the same, and a second cam opposed to the first for retracting the plunger upon a reversed movement of the former cam.

16. An internal combustion engine comprising a cylinder casing having a fuel injection port, there being a well in communication with said port, a plunger within said well, a spring for impelling said plunger in a direction to create a pressure within the well thereby to force fuel through the aforesaid port into the cylinder of the engine, a cam engaging element carried by said plunger, a cam for engagement with said element and normally movable in a given direction, said cam having an abrupt drop at one end whereby the plunger is instantaneously released upon the withdrawal of the cam from the aforesaid element, and a second cam opposed to the first cam and having an abrupt portion against which the aforesaid element normally engages, said second cam acting to retract the plunger to the maximum elevation of the former cam when the direction of said former cam is reversed.

17. An internal combustion engine comprising a cylinder casing having a cylindrical valve chamber, a fuel injection port leading therefrom into the engine cylinder, and a fuel supply port opening into said chamber; a valve element fitting within said chamber and having a bore, a port leading from the bore and adapted to register with the fuel injection port, and a passageway through which the supply port is adapted to communicate with the bore of the element when its respective port is out of register with the fuel injection port; means for rotating said element to successively bring its port and passageway respectively into register with the fuel injection port and fuel supply port; a plunger reciprocable within the bore of the valve element; and means for impelling the plunger in a direction to force fuel through the port of the elemert and the fuel injection port when said ports are in register.

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

LEE S. CHADWICK.

Witnesses:
W. E. SHEPPARD,
J. C. WALLACE.