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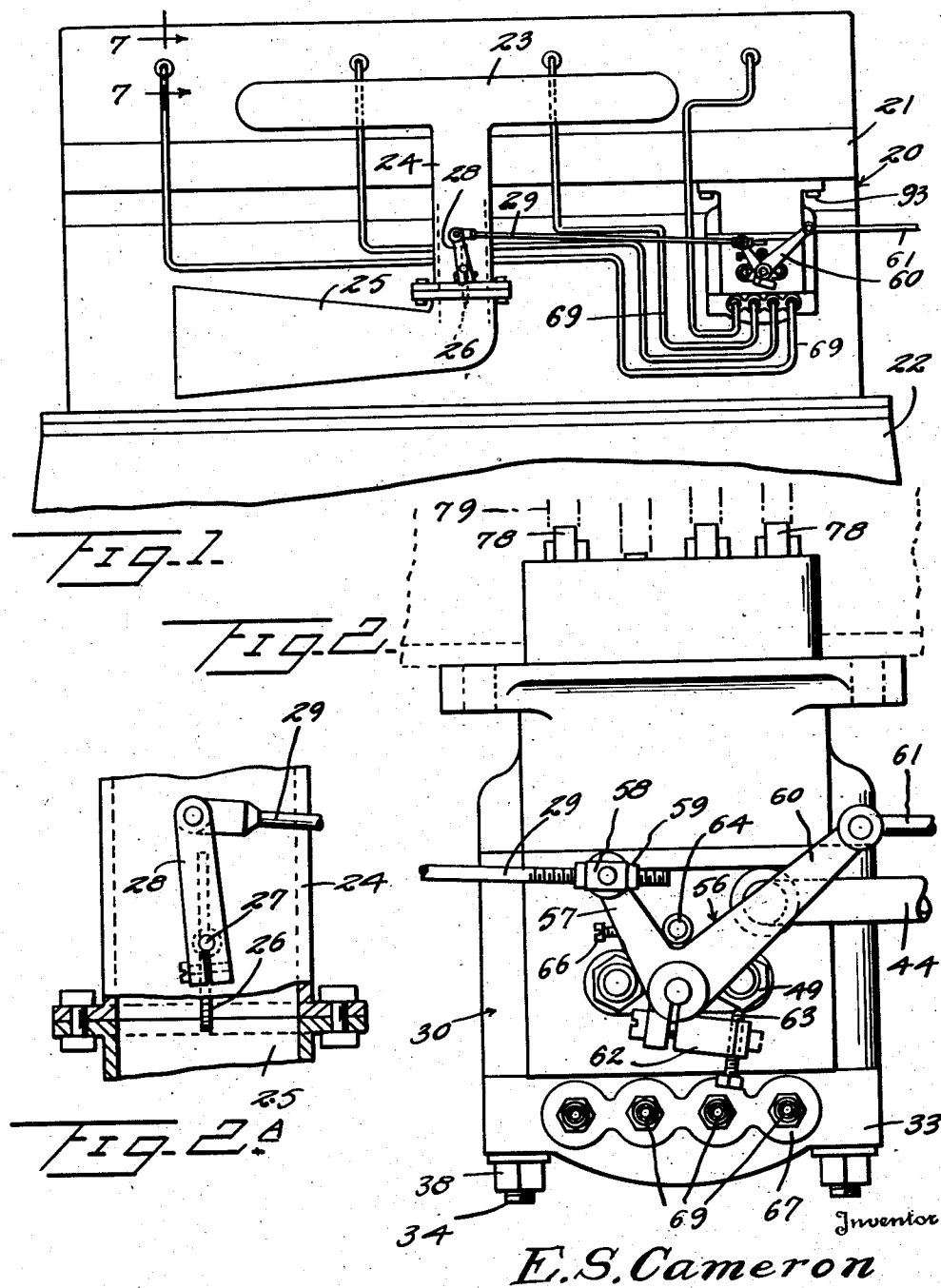
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2,369,134

FUEL INJECTOR SYSTEM

Filed March 17, 1942

7 Sheets-Sheet 1



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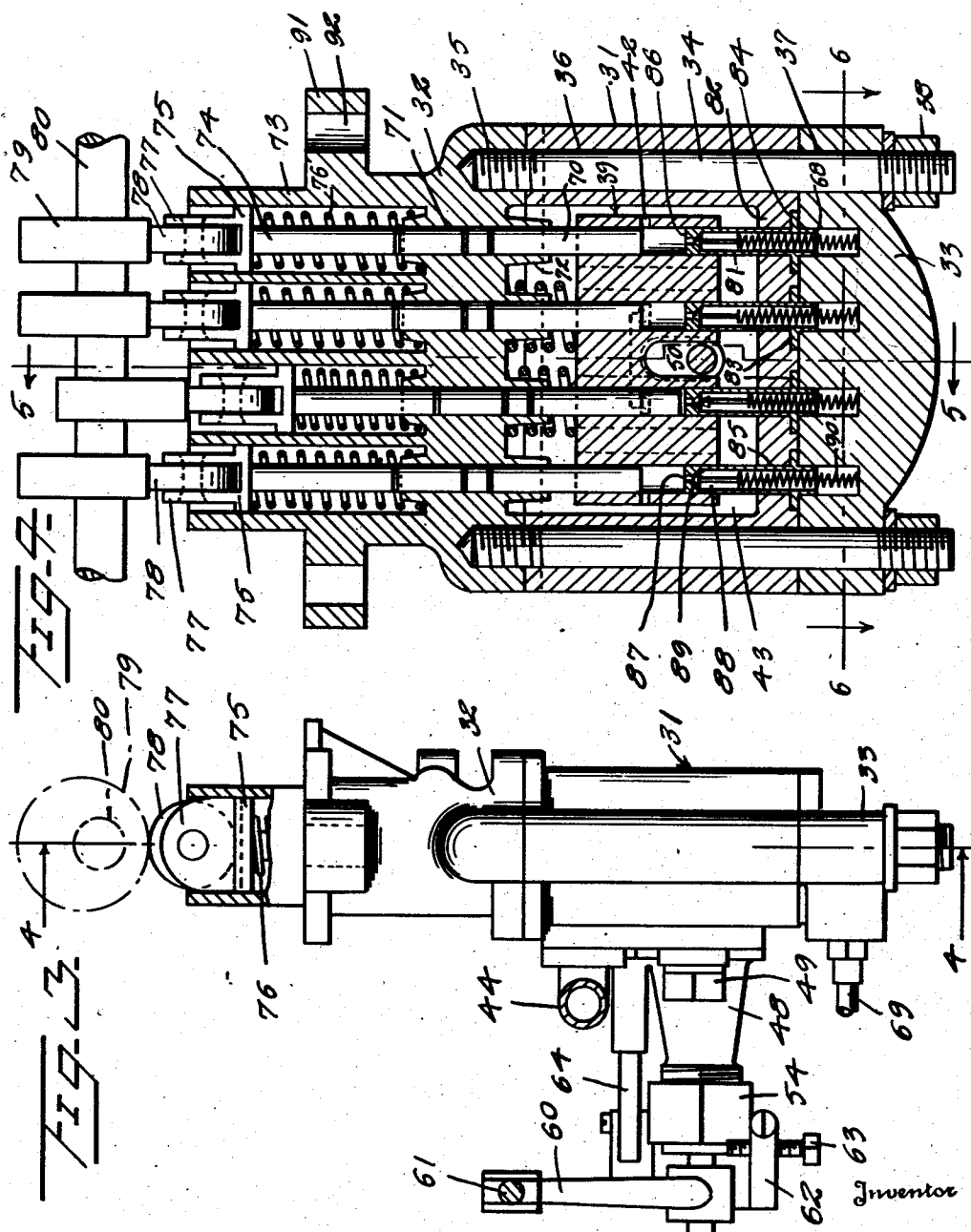
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FUEL INJECTOR SYSTEM

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7 Sheets-Sheet 2



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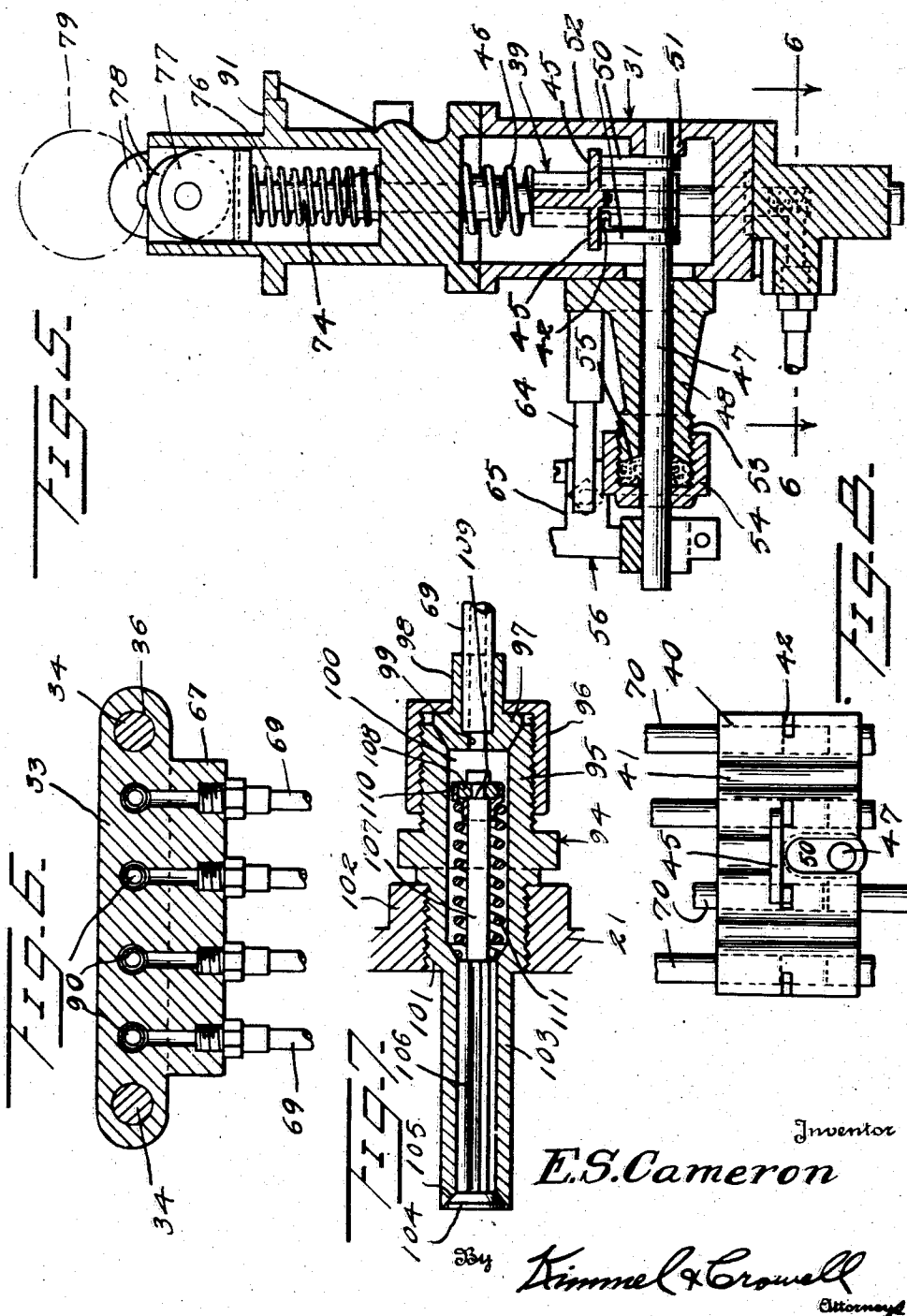
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FUEL INJECTOR SYSTEM

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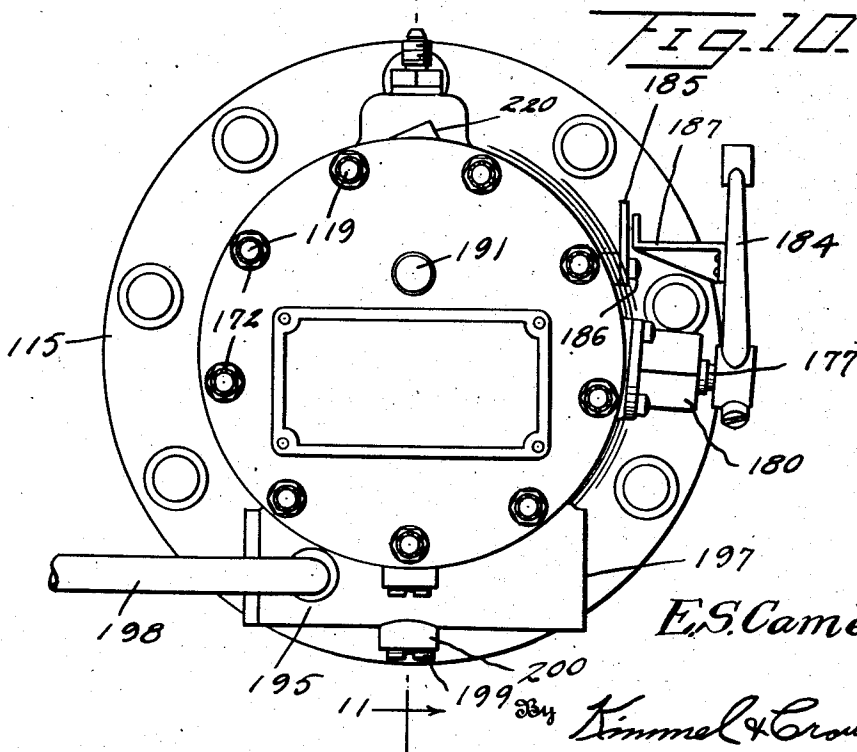
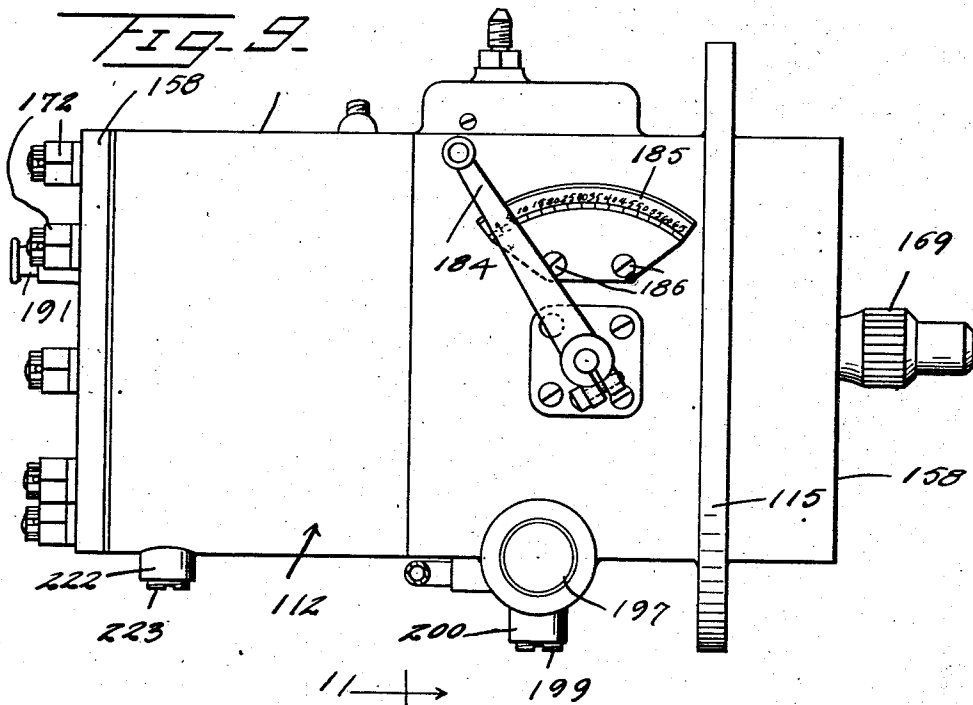
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FUEL INJECTOR SYSTEM

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7 Sheets-Sheet 4



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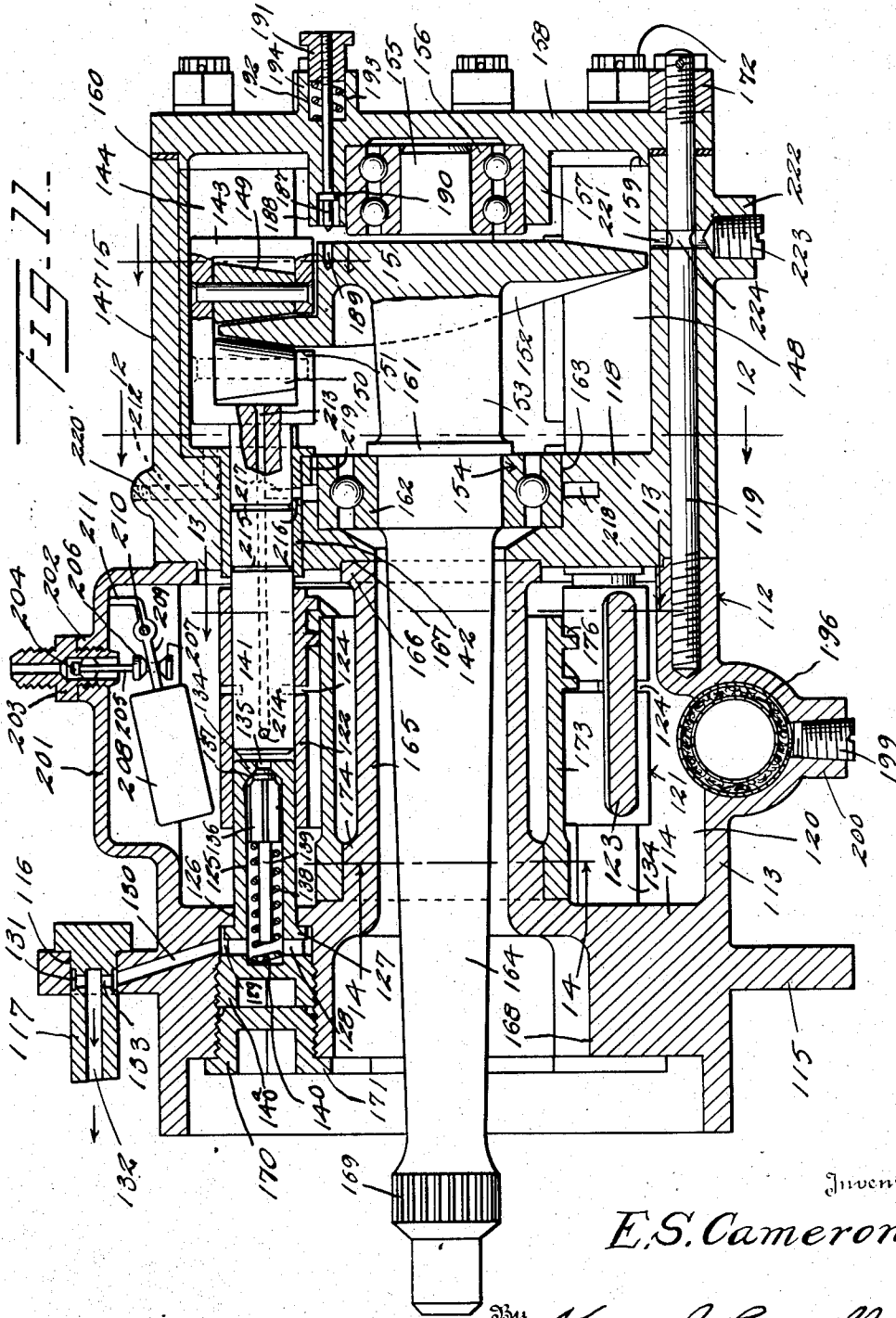
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FUEL INJECTOR SYSTEM

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7 Sheets-Sheet 5



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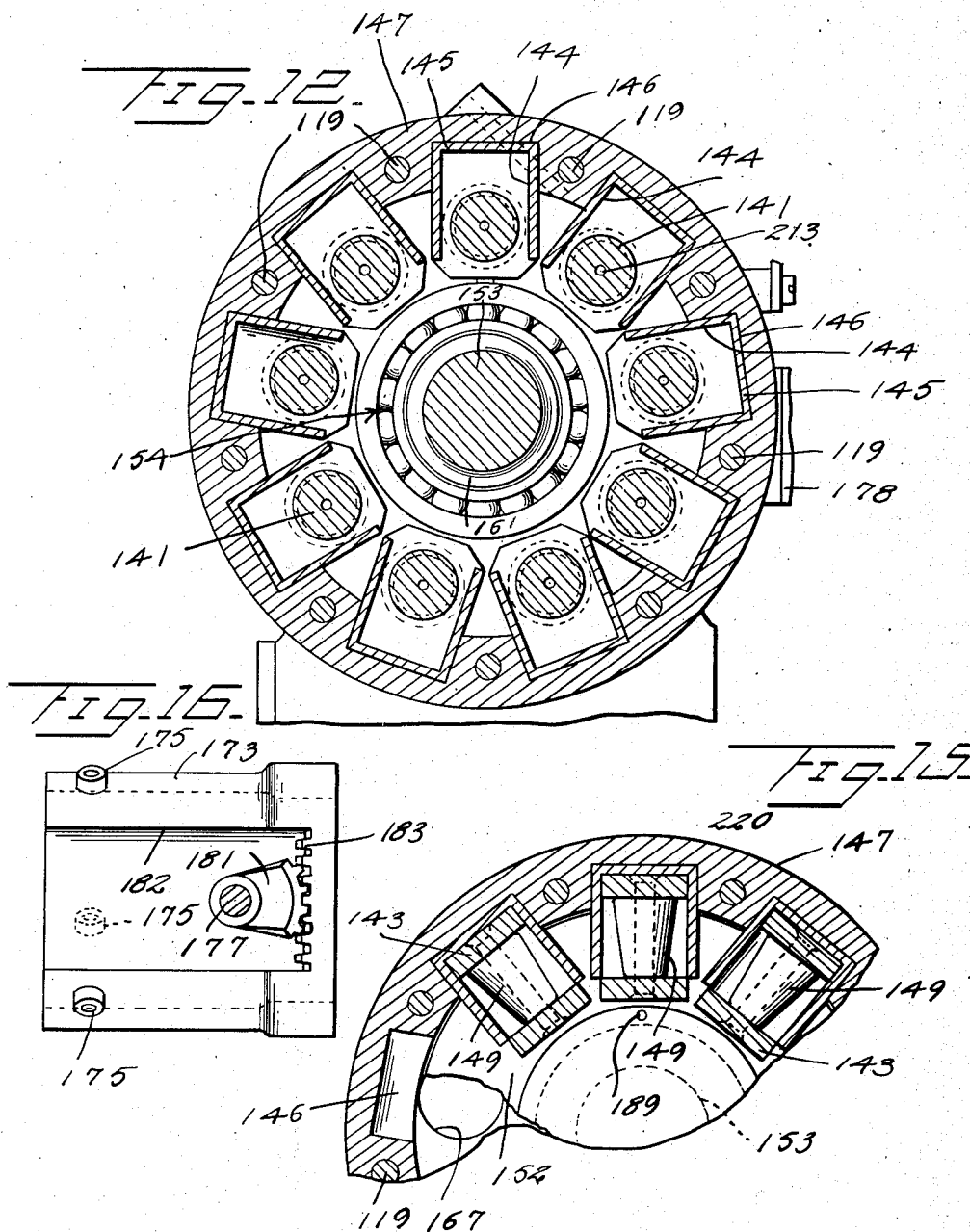
E. S. CAMERON

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FUEL INJECTOR SYSTEM

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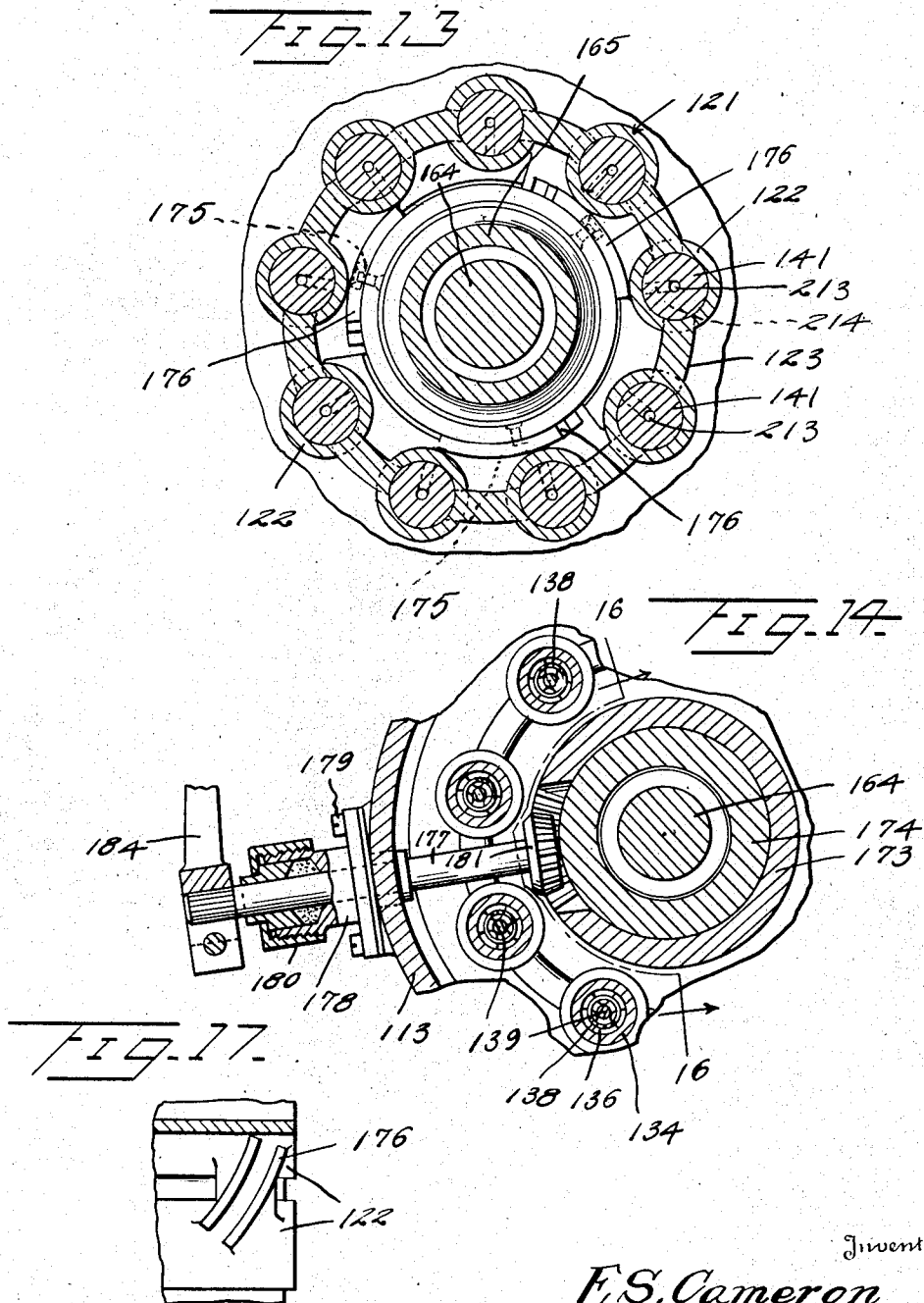
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E. S. CAMERON
FUEL INJECTOR SYSTEM

2,369,134

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7 Sheets-Sheet 7



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UNITED STATES PATENT OFFICE

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FUEL INJECTOR SYSTEM

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Application March 17, 1942, Serial No. 435,098

7 Claims. (Cl. 103—41)

This invention relates to internal combustion engines, and more particularly, to a fuel injector therefor.

An object of this invention is to provide in combination with an internal combustion engine and a throttle control a fuel injector for forcibly injecting fuel into the engine in a quantity proportionate to the throttle opening.

Another object of this invention is to provide a fuel injector of this kind which may be timed in its initial operation so as to inject the fuel at a predetermined piston position when the latter is on its suction stroke.

A further object of this invention is to provide a fuel injector which includes an adjustable cylinder structure operatively connected with the throttle, and a reciprocable piston structure operatively connected with the engine, the cylinder structure being adjustable with movement of the throttle to thereby provide for synchronism between the throttle and the fuel injection.

A further object of this invention is to provide an improved means for timing the fuel injection with relation to the position of the piston on the suction stroke of the latter.

A further object of this invention is to provide in a structure of this kind an improved means for eliminating any vapor or air lock within the structure.

A further object of this invention is to provide a device of this kind which will eliminate the usual carburetor and provide for the filling of the engine cylinders with air independent of the fuel injection.

A further object of this invention is to provide a device of this kind which is especially adaptable to airplane engines.

A further object of this invention is to provide a device of this kind which may be easily and quickly mounted on or removed from the engine.

A further object of this invention is to provide in a device of this kind a novel means for controlling the quantity of the fuel injected into the engine cylinders and also controlling time of injection of the fuel for predetermined portions of both the suction and compression strokes to thereby provide for the complete vaporization of the fuel and the mixture of the fuel with the air.

A further object of this invention is to provide an improved means for engine operation wherein the fuel injection occurs during the major portion of the suction stroke and also during a portion of the compression stroke, the injection during the compression stroke being cut off prior

to complete compression so as to prevent premature compression-ignition of the fuel.

To the foregoing objects and to others which may hereinafter appear, the invention consists of the novel construction, combination and arrangement of parts as will be more specifically referred to and illustrated in the accompanying drawings, wherein are shown embodiments of the invention, but it is to be understood that changes, variations and modifications may be resorted to which fall within the scope of the invention as claimed.

In the drawings:

Figure 1 is a detail side elevation of an internal combustion engine having a fuel injector constructed according to an embodiment of this invention mounted thereon,

Figure 2 is a detail side elevation of the injector structure,

Figure 2a is a fragmentary side elevation partly broken away and in section of the air intake manifold and butterfly valve,

Figure 3 is a detail end elevation partly broken away and in section of the injector,

Figure 4 is a sectional view taken on the line 4—4 of Figure 3,

Figure 5 is a sectional view taken on the line 5—5 of Figure 4,

Figure 6 is a sectional view taken on the line 6—6 of Figure 5,

Figure 7 is a sectional view taken on the line 7—7 of Figure 1,

Figure 8 is a detail side elevation partly broken away and in section of the cylinder assembly,

Figure 9 is a detail side elevation of a modified form of this injector structure,

Figure 10 is a detail end elevation of the structure shown in Figure 9,

Figure 11 is a longitudinal section taken on the line 11—11 of Figure 10,

Figure 12 is a sectional view taken on the line 12—12 of Figure 11,

Figure 13 is a sectional view on the line 13—13 of Figure 11,

Figure 14 is a sectional view taken on the line 14—14 of Figure 11,

Figure 15 is a fragmentary sectional view taken on the line 15—15 of Figure 11,

Figure 16 is a sectional view taken on the line 16—16 of Figure 14,

Figure 17 is a fragmentary sectional view looking from the inside of the cylinder assembly shown in Figure 13.

Referring to the drawings, and first to Figures 1 to 8, inclusive, the numeral 20 designates gen-

erally an internal combustion engine including a cylinder block 21 and a crank case 22. The engine 20 has disposed on one side thereof an air intake manifold 23 communicating with the several cylinders and the manifold 23 includes a depending tubular extension 24 having connected therewith a forwardly flared intake member 25. A butterfly valve 26 is secured to a shaft 27 which is journaled in the depending extension 24 and has fixedly secured to one end thereof a lever 28 which is adapted to be connected by means of a throttle rod 29 to a throttle operating element in the form of a pedal or the like.

In order to provide a means whereby the usual carburetor provided with internal combustion engines may be eliminated and the fuel forcibly discharged into the several combustion chambers forming the cylinder block 21, I have provided a fuel injector member generally designated as 30. The injector 30 comprises a hollow housing 31 which is provided with a head or cap member 32 and a base member 33. The housing 31, the cap 32 and the base 33 are held together in assembled relation by means of a plurality of bolts 34 which are threaded at their upper ends in threaded openings 35 formed in the lower side of the cap member 32 and extend through openings 36 formed in the housing 31. The bolts 34 also extend through openings 37 provided in the base member 31 and have threaded onto the lower ends thereof nuts 38 or the like.

A cylinder assembly generally designated as 39 is mounted within the housing 31 and comprises a plurality of vertically disposed open ended cylinders 40 which are connected together by webs 41. Each cylinder 40 is formed intermediate the upper and lower ends thereof with a slot or opening 42 communicating with the interior of the housing 31 which constitutes a fuel chamber or reservoir 43. Fuel is adapted to be discharged into the reservoir or chamber 43 from a fuel supply pipe 44 which is adapted to be connected to a fuel pump or the like. The cylinder assembly 39 is provided with a pair of oppositely extending flanges 45 which constitute cam engaging members for providing for the upward movement or adjustment of the cylinder assembly 39. A pair of expanding springs 46 are disposed within the housing 31 and bear at their lower ends against the innermost pair of cylinders 40 and bear at their upper ends against the lower side of the cap member 32.

A cam shaft 47 is journaled in a bearing 48 which is removably secured as by fastening members 49 to one side of the housing 31. The shaft 47 has fixed thereto within the fuel chamber 43 a pair of cam members 50 which are adapted to engage the lower sides of the flanges 45 so that the cylinder assembly 39 may be vertically raised within the housing 31 against the tension of the springs 46. The inner end of the shaft 47 is journaled in a bearing 51 carried by an adjacent side wall 52 of the housing 31. The bearing member 48 is provided at its outer portion with a threaded boss 53 about which a packing gland member or cap 54 is adapted to engage in order to compress a sealing member 55 against the outer end of the boss 53 and about the shaft 47. The shaft 47 has fixed to the outer end thereof a bell crank generally designated as 56. The crank 56 has one arm 57 thereof connected by means of a pivoted connector 58 to the forward end of the throttle rod 29. The rod 29 is lengthwise adjustable with respect to the connector 58 by means of adjusting nuts 59 which

engage on opposite sides of the connector 58. The bell crank 56 has the other arm 60 thereof connected by means of a rod 61 to a manually operable throttle controlling member in the form of a pedal or the like.

The bell crank 56 has fixed thereto a split lug 62 through which an adjustable stop screw 63 is threaded. The stop screw 63 is adapted upon rocking of the bell crank 56 in one direction to engage a stationary stop member 64 which is fixed relative to the bearing member 48. The bell crank 56 also has fixed thereto an inwardly projecting split lug 65 through which a second stop screw 66 is threaded. The screw 66 is adapted to engage the stop member 64 upon rocking of the bell crank 56 in the opposite direction. The stop members 63 and 66 provide a means whereby the cam shaft 47 may be limited in its rocking movement to thereby limit the vertical adjustment of the cylinder assembly 39.

The base member 33 is provided on the outer side thereof with a plurality of spaced apart bosses 67 which communicate with vertically disposed passages 68 formed in the base member 33. The bosses 67 are adapted to have connected therewith one end of fuel conducting pipes 69 which are adapted to be extended as shown in Figure 1 to the several cylinders forming the cylinder block 21. The several cylinders 40 have slidable therein a vertically reciprocable piston 70 which is slidable through an opening 71 formed in the cap member 32. The cap member 32 is provided with a depending guide member 72 extending downwardly from the cap 32 into the fuel chamber 43. The piston 70 is extended upwardly through the cap member 32 into an upper housing 73 which is formed integral with the cap 32. The piston 70 is provided with an extension 74 which terminates at its upper end in a head 75 slidable in the chamber or housing 73 which is formed as a cylinder. A spring 76 is disposed about the extension 74 and at its lower end bears against the upper side of the cap 32 and bears at its upper end against the underside of the piston head 75. The spring 76 constantly urges the piston structure including the piston 70 and the extension 74 upwardly to inoperative position. The head 75 is formed with a pair of upwardly extending ears 77 between which a roller 78 is rotatably mounted. The roller 78 is adapted to engage a cam member 79 which is fixedly secured to a cam shaft 80 disposed within the cylinder block structure 21 and operatively connected with the engine to rotate therewith. If desired, the cam shaft 80 may be formed as an integral part of the conventional cam shaft provided for operation of the intake and exhaust valves of the engine 20.

An upwardly extending exhaust valve sleeve 81 is carried by the bottom wall 82 of the housing 31 and is formed with a flange 83 seating in an annular recess 84 formed in the lower side of the wall 82. The sleeve 81 is extended upwardly through an opening 85 which is formed in the bottom wall 82, and preferably, the flange 83 is secured to the sleeve 81 upwardly from the lower end thereof so that a portion of the sleeve 81 will extend downwardly into the discharge opening 68 of the base member 33. The sleeve 81 is slidable within a cylinder 40 and is provided at its upper end with an upper end wall 86 having an opening 87 therethrough. An upwardly closing valve member 88 is slidably mounted within the sleeve 81 and is adapted to be constantly urged toward a valve seat 89 formed in the lower side

of the wall 86 by means of a spring 90. Downward movement of a piston 70 will force the fluid downwardly through the opening 87 and unseat the valve 88 against the tension of the spring 90 so that the fluid will pass out through the pipe 69 to the cylinder block 21 and discharge into a predetermined combustion chamber.

The cylinder structure or housing 73 formed on the upper side of the cap 32 is provided with a pair of laterally extending ears 91 formed with openings 92 whereby fastening members 93 may be used to secure the injector structure 30 to the appropriate portion of the engine 20. The opposite end of each pipe 69 is connected to a fuel injector nozzle structure generally designated as 94 which is threaded into the cylinder block or head structure 21 of the engine 20. The nozzle structure 94 includes a cylindrical body 95 having a cap 96 threaded thereonto which is adapted to compress a sealing member 97 for preventing leakage of any fluid through the outer end of the body 95. The cap 96 is formed with a cylindrical bushing 98 with which the adjacent end of the pipe 69 is adapted to be connected.

The sealing member 97 is formed with a centrally disposed opening 99 through which the fluid is adapted to pass for discharge into the fluid chamber 100 formed within the body 95. The body 95 is formed at its inner end with a threaded bushing 101 which is adapted to be threaded through a boss 102 formed in the adjacent side of the cylinder block or head 21. A cylindrical extension 103 is formed integral with the bushing or extension 101 and is adapted to project inwardly of the wall of the head or block member 21 and to extend interiorly of the combustion chamber of one of the cylinders forming the engine 20. A valve member or head 104 is adapted to engage a valve seat 105 which is formed at the inner end of the cylindrical extension 103 and the valve head 104 is formed with an outwardly extending stem 106 which extends through the extension 103 and terminates in a reduced stem 107 engaging within the chamber 100. A split washer 108 is mounted within an annular channel 109 which is formed adjacent the inner end of the stem member 107 and the split washer 108 is held within the groove or channel 109 by means of a retainer 110. An expanding spring 111 is disposed about the stem 107 and bears at its inner end against the inner end portion of the bushing 101 and bears at its outer end against the retainer 110, so as to thereby constantly urge the valve member or head 104 to a closed position. The pressure of the fluid in the chamber 100 formed by downward movement of an associated piston 70 will move the valve member 104 to an open or unseated position against the tension of the spring 111 so that the fluid may be discharged into the combustion chamber of the engine 20.

Referring now to Figures 9 to 17, inclusive, the numeral 112 designates generally a horizontally disposed fuel injector housing which is designed particularly for mounting on a radial internal combustion engine of the type used in aircraft. The housing 112 includes a hollow body 113 which is provided in the inner end thereof with an end wall 114 and is also provided with an annular flange 115 having a plurality of circumferentially spaced apart openings 116 through which fastening bolts 117 are adapted to engage for securing the housing 112 on the desired portion of the engine. The housing 112 also includes a cap or head 118 which is adapted to be secured to

the outer end of the housing 113 by fastening bolts 119. The housing 113 encloses a fuel chamber or reservoir 120 within which a cylinder assembly generally designated as 121 is adjustably positioned. The cylinder assembly 121 which is shown in Figure 13 comprises a plurality of circumferentially spaced apart cylinders 122 which are connected together by connecting webs 123. Each cylinder 122 is formed intermediate the ends thereof with a fuel intake opening or slot 124 communicating with the interior of a cylinder 122 and with the fuel chamber 120.

A plurality of circumferentially spaced apart valve housings 125 are carried by the inner end wall 114 and extend inwardly of the fuel chamber 120 through openings 126 formed in the end wall 114. The valve housings 125 extend slidably into the cylinders 122 and provide a supporting means for the cylinder assembly 121. Each valve housing 125 is formed at its outer end with a flanged head 127 having one or more radial grooves 128 formed in the outer portion thereof through which the fuel from the interior of the valve housing 125 is adapted to pass and the fuel discharged from the groove or grooves 128 passes into a chamber 129 formed in the end wall 114. A duct or passage 130 is formed in the end wall 114 communicating with the chamber 129 and also communicating with the bolt opening 116. Preferably, the bolt 117 is formed with a peripheral groove 131 which communicates with an axial bore or duct 132 formed in the bolt 127 by means of one or more radial openings 133. In this manner, the bolts 117 constitute not only a means for securing the housing 112 onto the engine, but also provide a means for communicating the fuel to the desired portion of the engine. By providing a fuel conducting means as hereinbefore described, the usual fuel conducting pipes may be eliminated and the removal of the housing 112 will also cut off or disengage the fuel connections of the housing 112 with the engine.

The valve housing or sleeve 125 is provided with an inner end wall 134 having an outlet port 135 axially thereof and a slidable valve 136 is adapted to be normally held on a valve seat 137 formed at the outer side of the wall 135 by means of a spring 138. The valve member 136 is provided with a stem 139 about which the spring 138 engages and the spring 138 at one end thereof is seated in a recess 140 which is formed in a threaded nut 140a. A fuel delivery piston 141 is slidable in each cylinder 122 and the piston 141 is also slidable through a sleeve 142 which is extended through the cap 118. The piston 141 at its outer end has secured thereto or formed integral therewith a roller cage 143. The cage 143 is slidable in a guide 144 which is U-shaped in transverse section and which is secured to or formed integral with the bearing sleeve 142. The guide 144 has the bight 145 thereof seated in a recess 146 which is formed in a cylindrical wall 147 formed integral with the cap 118 and extending outwardly therefrom.

The wall 147 encloses a cam chamber 148 which is also a lubricating chamber as will be hereinafter described. Each cage 143 has a pair of tapered rollers 149 and 150 rotatably mounted therein and the inner side of the cage 143 is provided with an opening 151 within which the tapered edge portion of a piston operating cam 152 is adapted to rotatably engage. The cam 152 is of substantially spiral configuration and is fixed to the outer end of a cam shaft 153 which

is journaled in an anti-friction bearing 154 carried by the cap 118. The shaft 153 is also provided at its outer end with a reduced stub 155 journaled in an anti-friction bearing 156, which is positioned within an annular bearing housing 157 carried by an outer plate or head 158. The belts 119 engage through the outer head or plate 158 and preferably the plate 158 is formed on its inner side with a rib or annular flange 159 providing a means for holding the plate 158 concentrically of the cylindrical wall 147. A gasket 160 may be interposed between the plate 158 and the outer end of the wall 147 to provide a liquid-tight seal for the chamber 148.

The cam shaft 153 is formed with an annular flange or rib 161 against which the inner race 162 of the anti-friction bearing 154 is adapted to engage so that the bearing 154 will be held against endwise movement in an outer direction with respect to the shaft 153. The bearing 154 is seated in an annular recess 163 which is formed in the outer side of the head or wall 118 concentrically of the annular series of pistons 141. The cam shaft 153 is formed with an inwardly tapering or reducing extension 164 which loosely engages through a cylindrical sleeve 165 which is formed integral with the inner end wall 114 and which extends concentrically through the fluid chamber 120. The outer end of the sleeve 165 is formed with a flange 166 which is seated in an annular recess 167 provided in the inner side of the head 118. The inner end wall 114 is also formed with a relatively large recess 168 through which the shaft extension 164 loosely extends and the inner end of the shaft extension 164 is provided with a splined coupling member 169 for connection to a rotating part of the internal combustion engine. The threaded nuts 140a are locked against rotation by means of a second nut constituting a lock nut 170 which is provided with a flange 171 abutting against the inner side of the end wall 114. The two nuts 140a and 170 are preferably of the socket type.

The bolts 119 at their outer ends have threaded thereonto nuts 172 which provide means for holding the housing 112 in assembled condition. The spiral cam 152 provides a positive means for effecting reciprocation back and forth of the pistons 141 in timed relation with respect to the movement of the engine pistons on the suction stroke of the latter and also on a portion of the compression stroke of the latter. The cylinder assembly 121 is shiftable endwise within the fluid chamber 120 by means of a cylindrical shifting member 173 which is rotatably mounted on a bushing or bearing 174 formed around the inner portion of the sleeve 165. The shifting member 173 is provided adjacent the outer portion thereof with a plurality of rollers 175 which are adapted to engage in a plurality of circumferentially spaced apart spiral channels 176 which are carried by the inner side of the cylinder assembly 121. In order to effect rotation of the cylinder assembly shifting member 173, I have provided a controlling shaft 177 which is journaled through a bearing or bushing 178 fixed by fastening devices 179 to the outer side of the housing 113. The shaft 177 is sealed with respect to the housing 113 by means of a packing gland 180 which is formed as a part of the bearing 178. The shaft 177 at its inner end has fixed thereto a fragmentary gear or quadrant 181 which is positioned in an elongated slot 182 formed lengthwise of the cylindrical shifting

member 173. The shifting member 173 at the inner end portion of the slot 182 is provided with gear teeth 183 with which the teeth of the quadrant 181 are adapted to engage. In this manner, rotation of the shaft 177 will effect rotation of the shifting member 173 and upon rotation of this member 173 the rollers 177 engaging in the spiral channels 176 will effect endwise adjustment or movement of the cylinder assembly 121.

The outer end portion of the shaft 177 has adjustably fixed thereto a lever 184 which is similar to the bell crank 56 and which is adapted to be connected with the butterfly valve shown in Figure 2a. The lever 184 is also adapted to be connected to a throttle controlling member (not shown) whereby the lever 184 may be rocked to the desired degree in order to effect opening of the butterfly valve and endwise adjustment of the cylinder assembly 121. The endwise adjustment of the cylinder assembly 121 provides a means whereby the space between the slots 124 and the inner ends of the valve housings 125 may be increased or decreased so as to provide for a greater or lesser quantity of fuel engaging within each cylinder 122. In other words, the endwise adjustment of the cylinder assembly 121 will have the effect of regulating the amount of fuel which is forced out of the cylinders 122 upon reciprocation of the pistons 141. This is accomplished without changing the stroke of the pistons 141.

In order to provide a means whereby the position of the cylinder assembly 121 may be visibly determined from the exterior of the housing structure 112, I have provided an arcuate gage 185 which is fixed by fastening devices 186 to the outer side of the housing structure 112. The lever 184 has fixed to the inner side thereof a pointer 187 which is adapted to move across the face of the gage 185 so that the position of the cylinder assembly 121 can be easily determined by the relative position of the lever 184 with respect to the gage 185.

The correct position of the spiral cam 152 is determined by means of a spring-pressed timing pin 187 which is slidable in a guide 188 carried by the plate 158. The outer side of the cam 152 is provided with a socket 189 within which the inner end portion of the pin 187 is adapted to engage so that when the pin 187 is manually forced inwardly into the socket 189, the correct position of the cam 152 can be determined, and particular positions of one or more of the pistons 141 can also be determined. The pin 187 has fixed thereto an annular rib 190 which provides a stop means for limiting the outward movement of the pin 187. A nut or knob 191 is threaded onto the outer end of a shaft 192 which is formed integral with the pin 187 and a spring 193 is mounted in a bushing 194 carried by the head 158 and bears at its inner end against the head or plate 158 and at its outer end against the nut or button 191.

The housing 113 is provided on the lower side thereof with an intake housing 195 having positioned therein a screen or filter element 196. The housing 195 is adapted to have one end of a fuel pipe line connected therewith, the fuel pipe line being connected at the end 197 which constitutes the intake end of the housing 195. The housing 195 also has connected thereto a pipe 198 which may be extended to a pressure gage so that the pressure of the fuel in the chamber 120 can be determined from a point remote from the hous-

ing 112. The intake housing 195 is provided with a removable drain plug 199 which is threaded into a bushing 200 formed integral with the housing 195.

In order to provide a means whereby the accumulation of any vapor or air within the chamber 120 may be automatically released, I have provided a dome 201 which is formed as an integral part of the housing 113 on the upper side thereof, and which constitutes also a float chamber. The dome 201 is formed with an upstanding boss 202 in which a combined valve seat and coupling member 203 is threaded. A vertically movable valve member 204 is disposed within the coupling 203 and is provided with a stem 205 extending downwardly into the float chamber and terminating in a pair of spaced apart ribs 206 and 207. A buoyant float member 208 is disposed within the float chamber 201 and has fixed thereto a bifurcated lever 209 which is pivotally mounted on a stationary pivot 210 extending transversely through the float chamber 201. The lever 209 at its outer or forward end terminates in an L-shaped member 211 which constitutes a means for limiting the downward movement of the float 208 when the fluid in the chamber 120 does not completely fill the chamber 120 and also the chamber of housing 201.

The vertical leg of the L-shaped stop member 211 is adapted to engage the upper or top wall of the housing 201 when the quantity of fluid in the housing or chamber 201 drops to a predetermined degree and at this time the valve member 204 will be in an unseated position with respect to the valve seat formed in the combined coupler and valve seat member 203.

In order to provide a means whereby the movable parts of this injector may be constantly lubricated, I have provided a lubricating duct 212 which is formed in the head 118 and which discharges into the lubricating chamber 148. Each piston 141 is formed with a longitudinal lubricating duct 213 which extends through a cage 143 and communicates at its outer end with the chamber 148. The duct 213 is slightly less than the length of the piston 141 and the piston 141 is provided with one or more radial passages 214 opening through the periphery of the piston 141. The piston 141 may also be provided with a plurality of annular lubricating grooves 215 outwardly of the radial openings 214 and the bearing sleeve 142 may be provided with an opening 216 which is adapted to communicate with a radial passage 217 communicating with the central duct 213. The head 118 is formed with an annular lubricating channel 218 engaging about the outer race of the bearing 154 and with which the openings 216 of the bearings 142 are adapted to communicate. The head 118 is also provided with lubricating passages 219 communicating the chamber 148 with the annular lubricating channel 218. The return of the lubricant from the chamber 148 to the engine is effected by passage of the lubricant through the antifriction bearing 154 and then through the interior of the sleeve 165.

The head 118 is formed with a boss 220 with which a lubricant conducting pipe is adapted to be connected from a suitable pressure source forming part of the internal combustion engine. As the housing 112 is connected to one side or end of the engine, the sleeve 165 may communicate with the crank case or other reservoir for the lubricant which is already provided in the internal combustion engine.

In the use and operation of this structure and referring first to Figures 1 to 8 inclusive, the operation of the engine 20 is controlled by endwise movement of the throttle controlling rod 61. Movement of the rod 61 will rock the bell crank 56 which will in turn rock the butterfly valve 26 to the desired open position in order to permit controlled entrance of air into the air intake manifold 23. Rocking of the bell crank 56 will rock the cam shaft 47 which will thereby effect vertical adjustment of the cylinder assembly 39. The vertical adjustment of the assembly 39 will provide for increasing or decreasing the space between the lower ends of the pistons 70 and the upper wall 86 of the valve sleeve 81. As the fluid in the chamber 43 is under constant pressure when a piston 70 rises above a slot 42 the fluid will enter the cylinder 40 between the lower end of the piston 70 and the upper end of the valve structure 81. Downward movement of the piston 70 past the intake port 42 will close the port 42 and further downward movement will cause the fluid in the cylinder 40 to unseat the valve 88 and this fluid will then be forced out of the base member 33 into the fluid conducting pipe 69.

The pressure of the fluid in the pipe 69 will unseat the valve 104 carried by the nozzle 103 thereby discharging the fluid within the combustion chamber of the engine structure. Preferably, the operation of a piston 70 on its fluid ejecting stroke is timed so that the fluid will initially begin discharging into the combustion chamber of the engine at the time the crank shaft of a particular engine piston is about five degrees beyond the top center thereof and the engine piston associated therewith has started downwardly on its suction stroke. The fluid ejecting piston 70 is also so timed in its movement toward fluid ejecting position so that the ejecting operation will continue from a five degree position off top center of the crank shaft to a position about thirty-five degrees after the crank shaft has passed the bottom center of its movement. In other words, the piston 70 will continue ejecting fuel into the combustion chamber of the engine during the entire suction stroke of the engine piston and will also continue to discharge fuel for a portion of the compression stroke of the engine piston.

The injector provides a means for positive injection of fuel into the combustion chamber and cylinder of an engine so that suction provided in the engine cylinder by downward movement of the piston will only draw in air which is taken from the manifold 23 and the quantity of this air is regulated by the position of the butterfly valve 26.

Referring now to Figures 9 to 17 inclusive, the injector structure therein disclosed operates as follows: The cam shaft 153 is connected by means of the coupling element 169 to a rotating part of the engine which may be a radial airplane engine and the bolts 117 are adapted to secure the housing structure 112 on the desired part of the engine. Rotation of the cam shaft 153 will effect rotation of the cam 152 which will in turn effect positive reciprocation back and forth of the circumferentially arranged pistons 141. The amount of fluid forced out of the cylinders 122 by the pistons 141 is determined by the relative position of the cylinder assembly 121 with respect to the valve housings 125. In the position of the cylinders 121 shown in Figure 11, the injector structure is in its fullest open position and

discharging the greatest amount of fluid through the valve housings 125 and the conducting passages 130 to the ducts 132 which are formed in the securing bolts 117. Endwise movement to the left of the assembly structure 121 will shorten the distance between the inner ends of the valve housings 125 and the intake ports 124 so that when the pistons 141 are reciprocated a smaller quantity of fuel will be forced out of the pistons 122. In order to provide for draining of the lubricating chamber 148, the wall 147 is provided with an opening 221 which communicates with a boss 222 having a threaded plug 223 mounted therein. One of the bolts 119 is formed with an annular groove or channel 224 so that the lubricant may flow from the opening 221 through the threaded opening in the boss 222.

At full throttle, with the butterfly valve 26 in a wide open position, the cylinder assembly 39 will be in a position with the intake ports 42 the greatest distance from the valve housings 81. At this time each piston 70 will start ejecting fuel from a cylinder 40 as soon as the piston passes the port 42 which occurs at the beginning of the ejecting stroke of the piston. In this position of the cylinder assembly, the fuel injection into the engine cylinders starts when the crankshaft is about five degrees past top center, and continues until the crankshaft has moved to a position of about thirty-five degrees beyond bottom center or until the engine piston has moved upward on its compression stroke.

Assuming that the engine is throttled down, the butterfly valve 26 will be partly closed to restrict the air admission, and at this time, the cylinder assembly 37 will be moved in the direction of the bottom wall 82 by means of the springs 46. At all throttle positions, the pistons will travel the same distance, but with the assembly 39 moved toward the wall 82 the port 42 of each cylinder 40 will be closer to the adjacent end of the valve housing so that when the piston 70 moves on the ejecting stroke thereof, a smaller quantity of fuel will enter each cylinder 40 for injection into the engine cylinder. At this time, that is, at reduced throttle position, the initial movement of the piston 70 will be an idling movement as the inner end of the latter is disposed above the intake part 42 and any fuel in this portion of a cylinder 40 will be forced out through the intake port and back into the fuel chamber 43. At reduced throttle position, the fuel injection into the engine cylinders occurs beyond the five degree past top center position of the crankshaft proportionate to the throttle position, but the end of the fuel injection cycle occurs at the same time, that is, at about thirty-five degrees past bottom center of the crankshaft, for all throttle positions.

What I claim is:

1. A fuel injector comprising a housing for connection with a source of fuel under pressure, a fuel chamber in said housing, a cylinder assembly in said chamber including a plurality of parallel cylinders, webbing connecting said cylinders together, an injector piston for each cylinder slidably carried by said housing, a check valve for each cylinder fixed relative to said housing and slidably engaging in a cylinder, each cylinder having an intake port intermediate the ends thereof, and means for adjusting said cylinder assembly relative to said check valves to thereby regulate the quantity of fuel ejected from a cylinder upon reciprocation of a piston said adjusting means including a laterally projecting lug

carried by said webbing, and cam means carried by said housing engaging the lug for shifting the cylinder assembly to thereby vary the cutoff of said ports during the injection cycle of said pistons.

2. A fuel injector comprising a housing for connection with a source of fuel under pressure, a fuel chamber in said housing, a cylinder assembly in said chamber including a plurality of parallel cylinders, webbing connecting said cylinders together, an injector piston for each cylinder slidably carried by said housing, a check valve for each cylinder fixed relative to said housing and slidably engaging in a cylinder, each cylinder having an intake port intermediate the ends thereof, means for adjusting said cylinder assembly relative to said check valves to thereby regulate the quantity of fuel ejected from a cylinder upon reciprocation of a piston, said adjusting means including a laterally projecting lug carried by said webbing, and cam means carried by said housing engaging the lug for shifting the cylinder assembly to thereby vary the cutoff of said ports during the injection cycle of said pistons and means for reciprocating said pistons.

3. A fuel injector comprising a housing having a fuel chamber therein, a cylinder assembly in said chamber including a plurality of parallel cylinders, webbing connecting said cylinders together, reciprocable ejecting pistons slidable in the cylinders of said assembly, means for reciprocating said pistons, each cylinder of said assembly having an intake port intermediate the ends thereof, check valve means carried by said housing and engaging within the cylinders of said assembly, and means for adjusting the position of said assembly relative to said check valve means to thereby vary the quantity of fuel admitted into each cylinder for ejection by said pistons said adjusting means including a laterally projecting lug carried by said webbing, and cam means carried by said housing engaging the lug for shifting the cylinder assembly to thereby vary the cutoff of said ports during the injection cycle of said pistons.

4. A fuel injector comprising a housing having a fuel chamber therein, a cylinder assembly in said chamber including a plurality of parallel cylinders, webbing connecting said cylinders together, reciprocable ejecting pistons slidable in the cylinders of said assembly, means for reciprocating said pistons, each cylinder of said assembly having an intake port intermediate the ends thereof, check valve means carried by said housing and engaging within the cylinders of said assembly, a lug projecting from said webbing, and cam means engageable with said lug for adjusting the position of said assembly relative to said check valve means to thereby vary the quantity of fuel admitted into each cylinder for ejection by said pistons.

5. A fuel injector comprising a housing for connection with a source of fuel under pressure, a fuel chamber in said housing, a cylinder assembly comprising a plurality of parallel connected cylinders in said chamber, each cylinder having an intermediate intake port communicating with said chamber, a check valve for each cylinder fixed to said housing and projecting into one end of said cylinder, an injector piston for each cylinder carried by said housing and slidable in the opposite end of said cylinder, means for reciprocating said pistons, said ports being so positioned that movement of said pistons inwardly of said cylinders will cut off said ports, means for ad-

justing said assembly endwise to thereby vary the cutoff of said ports, said assembly including a cylindrical web fixed to said cylinders, and spiral ribs carried by said web, said adjusting means engaging said ribs.

6. A fuel injector comprising a housing for connection with a source of fuel under pressure, a fuel chamber in said housing, a cylinder assembly comprising a plurality of parallel connected cylinders in said chamber, each cylinder having an intermediate intake port communicating with said chamber, a check valve for each cylinder fixed to said housing and projecting into one end of said cylinder, an injector piston for each cylinder carried by said housing and slidable in the opposite end of said cylinder, means for reciprocating said pistons, said ports being so positioned that movement of said pistons inwardly of said cylinders will cut off said ports, means for adjusting said assembly endwise to thereby vary the cutoff of said ports, said assembly including a cylindrical web fixed to said cylinders, spiral ribs carried by said web, said adjusting means

including a cylindrical member rotatably carried by said housing within said web, rollers carried by said cylindrical member engaging between said ribs, and means for rotatably adjusting said cylindrical member to thereby adjust said assembly endwise.

7. A fuel injector comprising a housing having a fuel chamber therein, a cylinder assembly movable endwise in said chamber including a plurality of parallel cylinders, webbing connecting said cylinders together, each cylinder of said assembly having an intake port communicating with said chamber, means for ejecting fuel from a cylinder, and means for adjusting said assembly endwise to thereby vary the quantity of ejected fuel, said adjusting means including a laterally projecting lug carried by said webbing, and cam means carried by said housing engaging the lug for shifting the cylinder assembly to thereby vary the cutoff of said ports during the injection cycle.

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