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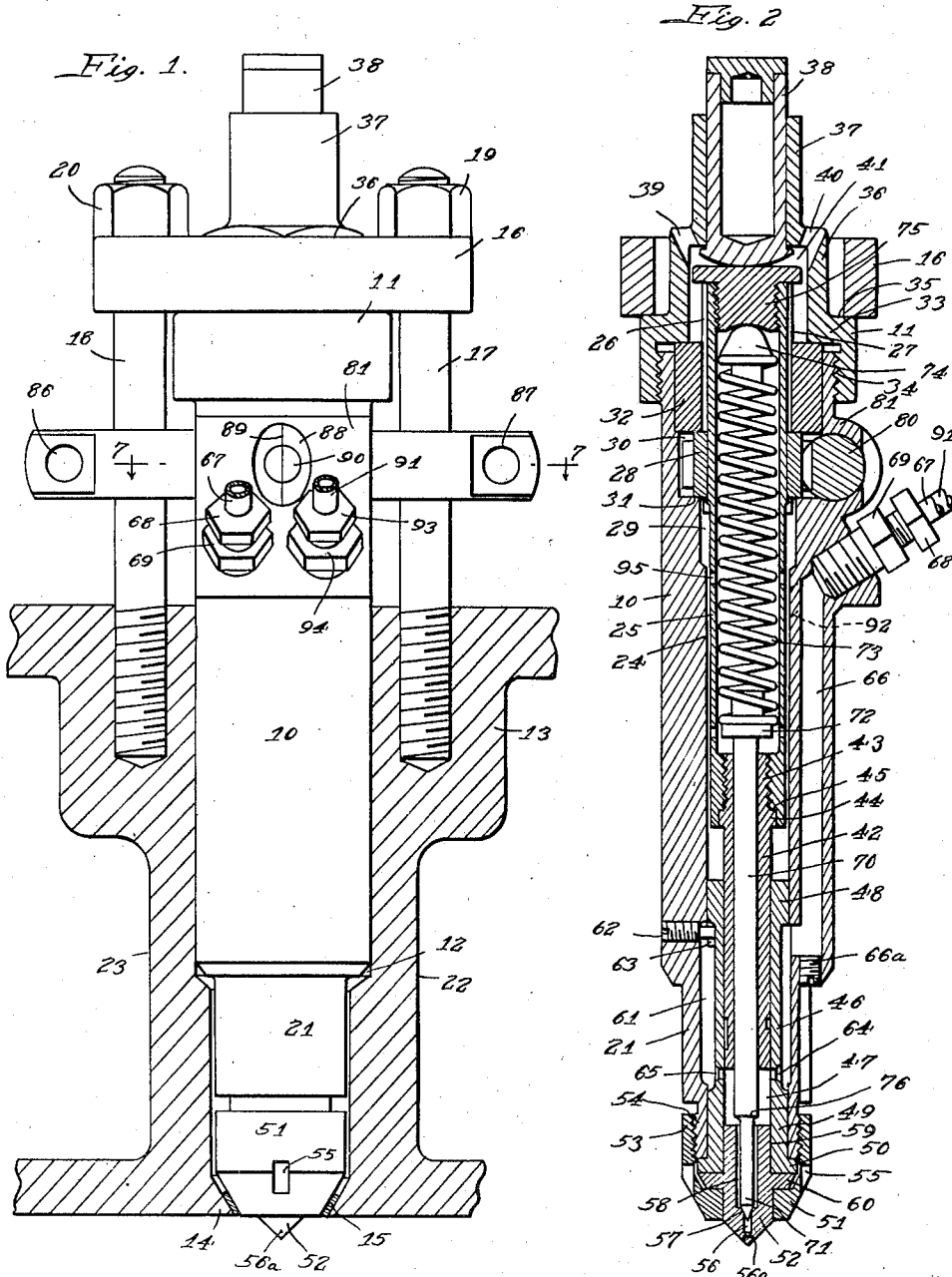
F. RITZ

1,944,371

INJECTOR

Filed June 25, 1930

2 Sheets-Sheet 1



Inventor:
By Frederick Ritz
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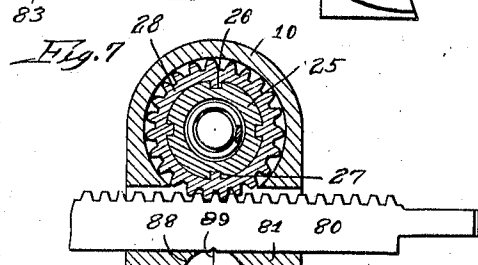
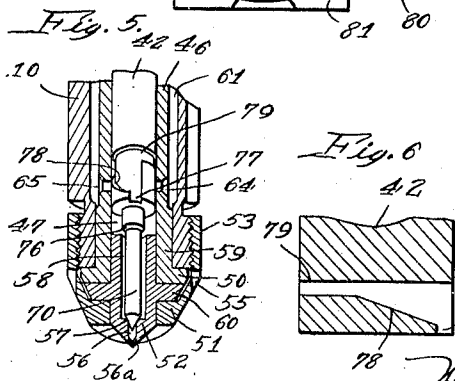
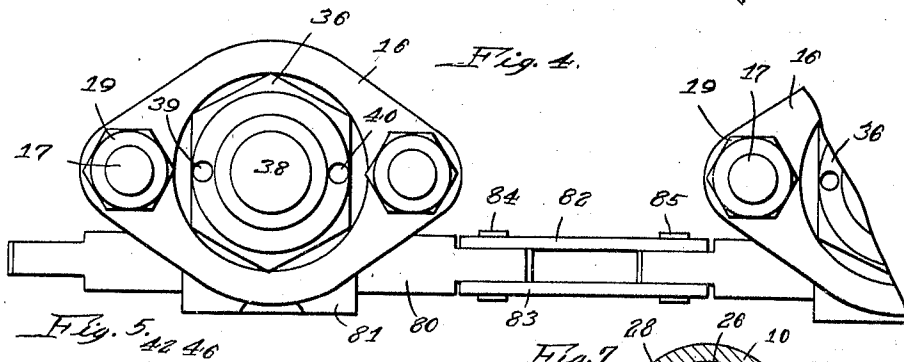
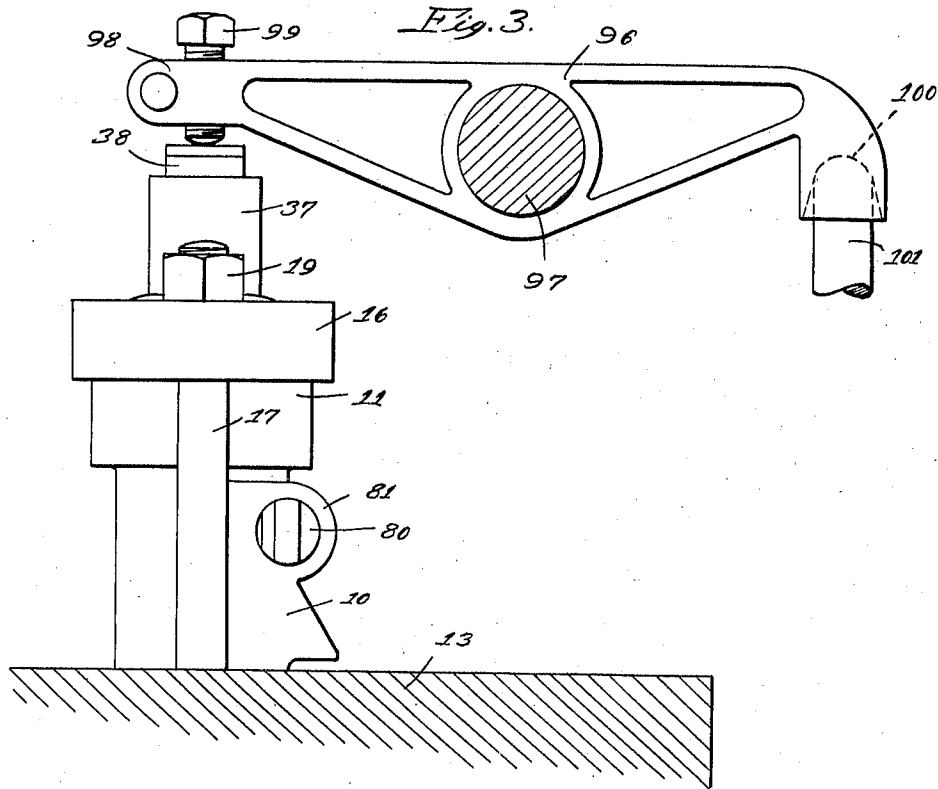
F. RITZ

1,944,371

INJECTOR

Filed June 25, 1930

2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

1,944,371

INJECTOR

Frederick Ritz, Beloit, Wis.

Application June 25, 1930, Serial No. 463,605

22 Claims. (Cl. 299—107.2)

My invention relates to fuel injectors for internal combustion engines and has particular reference to a combined fuel pump and injector nozzle for Diesel engines.

5 It is customary in fuel supply systems for Diesel engines to provide a plurality of fuel pumps, one for each cylinder of the engine, operated by a cam shaft driven from the motor. These pumps are connected through fuel lines to injector nozzles positioned in the cylinder walls of the motor and arranged to spray the fuel into the cylinders. While various modifications of this type of fuel supply system and various other systems are known the objections and defects of this system are more or less common to all and I will, therefore, discuss my invention and set forth the advantages thereof with respect to this particular system.

10 It is highly desirable to regulate the amount of fluid injected into the cylinder with extreme accuracy. This is particularly true with the smaller high-speed engines which are to be operated under varying speed and load conditions. Considerable difficulty, however, is experienced in accurately regulating the amount of fluid injected and it is with this regulation and the manner of injection that my invention is particularly concerned. The fluid must be injected into the cylinder against a comparatively high cylinder pressure, in the region of 500 pounds per square inch and greater. Therefore, the injection pressure must be sufficient to spray the liquid fuel into the chamber against this pressure. Where a pump and a fuel line connected to the nozzle are employed, it will be seen that the hydraulic pressure upon these parts must be relatively high to accomplish the purpose. The lines and joints of the system tend to expand when this high injection pressure is placed upon the system and to contract when it is released. This obviously tends to reduce the accuracy of injection of the system and becomes so serious as to positively prevent the injection of minute quantities of fuel, such as normally required when the motor idles. It has, therefore, been found to be advantageous, when the motor operates under light loads or when it idles, to employ a low injection pressure. This results in a smoother running motor. On the other hand, experience shows that when the motor operates under a heavy load or at high speeds it is advantageous to employ a high injection pressure. In other words, it is advantageous to fit the injection pressure to the load and this is done in the older type of systems by manually adjusting the pressure on the loading

springs. In some instances special devices have been employed to permit simultaneous changes in the pressure on the loading springs, permitting them all to be changed to the same degree.

To obtain a good mixture and smooth running of the engine it is desirable to inject the fuel at a gradually increasing fuel velocity, whereby the injection pressure will be different during each time element of the injection period. The low injection velocity at the beginning causes the first globules of fuel to travel only a short distance into the combustion space, and they ignite and burn in the proximity of the nozzle. The following fuel globules which enter with an increasing velocity, penetrate farther into the combustion chamber, force their way through the flame zone and reach fresh air, where they can burn. If the injection velocity is held constant as is the case with the older fuel systems, the fuel injected toward the end of the injection period remains in a space already filled with burned gases of the fuel that was injected at the beginning of the injection period.

15 It should further be noted that in systems of the character under discussion a large amount of liquid fuel is placed under pressure between the fuel pump and the spray nozzle tip. Due to the compressibility of the fuel the system becomes inaccurate and sluggish in operation. Due to this compressibility of the fuel and to the expansion of the fuel lines it becomes necessary to so adjust the pump that the stroke thereof will occur a predetermined period of time before injection onto the combustion chamber is actually desired. For example, it may be necessary to provide the stroke of the pump at a time when the piston has 15° to travel before the injection is actually desired. This is due to the fact that a pressure must actually be built up within the large volume of fluid being compressed. Now if the pump is set 15° ahead of the piston under full load and the motor is shifted to an idling speed, the pressure on the fuel becomes less and the lag becomes greater. Therefore, at the lower speed the injection will be late and the motor will smoke and fail to idle well.

The periodic building up and releasing of the pressure in the fuel lines results in a series of waves or oscillations passing along the fuel. When the pump is acting under a low injection pressure it will be seen that the impulse of the pump and one of these waves may meet at a point intermediate between the nozzle and the pump, in which case an insufficient amount of pressure will be exerted on the valve stem in the nozzle and

no fuel will be injected. On the other hand, at the next stroke of the pump the wave and the impulse of the pump may coincide at the nozzle, in which case an excessive amount of fuel will be injected into the combustion chamber. This causes uneven operation of the motor. Clearly the smaller the amount of liquid acted upon by the fuel pump the smaller the amount that can be injected at each stroke of the pump.

10 I have, therefore, aimed to provide an injector in which the fuel pump and the injection nozzle are incorporated into a single unitary structure.

Another object of the invention is the provision of a liquid fuel supply system for Diesel engines 15 having an injection nozzle employing a hydraulic valve in which the opening pressure is substantially lower than the closing pressure thereof.

Another object of the invention is the provision of an injector wherein there are no fuel lines 20 under any substantial amount of pressure.

Another object of the invention is the provision of an injector in which only a very small amount of fluid is acted upon at each stroke of the fuel pump.

25 I have further aimed to provide an injector wherein the valve closing pressure is automatically increased as the load or speed of the motor is increased.

A still further object of the invention is the provision of an injector wherein liquid fuel is 30 supplied to a pump chamber positioned directly adjacent to the tip of the spray nozzle at which point it is compressed and injected into the combustion chamber through a hydraulically operated valve arranged to open when the hydraulic pressure reaches a desired point.

I have also aimed to provide an injector in which injection will begin to occur at a relatively low pressure and cease at a relatively high pressure and in which the tension on the loading spring will gradually increase as injection proceeds, reaching its highest point at the time when the pressure on the fuel is relieved, whereby the valve is caused to close with great speed and drip 45 is substantially eliminated.

Another object of the invention is the provision of an injector comprising a combined fuel pump and injection nozzle located in the walls of the cylinder and arranged to be actuated by a cam 50 or a cam and rocker arm.

Other objects and attendant advantages will become apparent to those skilled in the art from the following description and the accompanying drawings in which—

55 Figure 1 is a section through the walls of a conventional Diesel engine cylinder showing the injector in elevation

Fig. 2 is a vertical section through the injector;

60 Fig. 3 is a vertical elevation partly in section showing the manner in which the injector may be operated by means of a conventional rocker arm;

Fig. 4 is a fragmentary top view of a multiple cylinder engine showing the manner in which the injectors are governed;

65 Fig. 5 is an enlarged section through the lower end of the injector showing the lower end of the fuel pump and the valve stem;

Fig. 6 is a development showing the surface on the pump plunger; and

70 Fig. 7 is a section on the line 7—7 of Fig. 1.

The invention consists in a general way of a casing arranged to be positioned in the cylinder walls of a conventional Diesel engine, the casing being provided with a sleeve having a central 75 opening arranged to receive a spring. The lower

end of the sleeve is provided with a pump plunger arranged to extend to a nozzle tip positioned on the bottom end of the casing, the lower end of the casing being arranged to provide a pump cylinder. A valve stem is slidably positioned in the 80 pump cylinder, projecting out of the lower end thereof to engage the nozzle orifice and out of the upper end thereof into said sleeve whereby said spring may exert a downward pressure thereon. Means are provided for supplying fuel 85 to the pump cylinder, the plunger being arranged to compress the fuel in the pump cylinder with downward movement of said sleeve. When the pressure on the fuel reaches a predetermined point the valve will be hydraulically opened 90 against the pressure of the spring to permit a predetermined amount of fuel to be injected into the cylinder. Means are provided for releasing the pressure on the fuel when a predetermined amount has been injected whereby the valve 95 may return to its closed position. A cam may be caused to operate the plunger in timed relation with the movement of the piston through an intermediary rocker arm or as desired.

Referring first to Figs. 1 and 2, a casing designated generally by the numeral 10, having a cap 11, is arranged to be positioned within an opening 12 in the cylinder wall 13 of a Diesel engine. The lower end of the opening 12 may be tapered inward as shown at 14 to support a gasket or 105 packing 15 between the cylinder wall 13 and the injector to prevent the passage of gas there-through. The injector may be secured within the opening 12 through a yoke 16 arranged to bear against the cap 11 and be drawn downward by means of bolts 17 and 18 and nuts 19 and 20, the bolts being secured in the cylinder wall 13 in an obvious manner. The lower end of the casing 10 may be constricted as shown at 21 in order to reduce, in so far as possible, the size of the opening 12 which must pass between the water chambers 22 and 23 on either side thereof. It might sometimes be advisable to cause the casing 10 to pass directly through a water chamber and merely secure the casing 10 at each end. 120

Referring now more particularly to Fig. 2, the casing 10 is provided with a central opening 24 arranged to receive a sleeve 25 therein. The upper end of the sleeve 25 is provided with splines 26 and 27 to receive a feathered pinion 28 presently to be described more in detail. The opening 24 in the casing 10 is slightly enlarged at 29 to permit rotation and endwise movement of the sleeve 25. The opening 24 is further enlarged at 30 to receive the pinion 28 and permit the rotation thereof with the sleeve 25. Downward movement of the pinion 28 may be prevented by providing a shoulder 31 at the junction of the openings 30 and 29, the pinion having thrust bearing thereon. A collar 32 is positioned in the upper end of the casing 10 and limits the upward movement of the pinion 28, the collar permitting the sleeve to have endwise movement. The collar 32 is held within the casing 10 by the inner edge 33 of the cap 11, the cap having 140 threaded engagement with the upper end of the casing 10 as shown at 34. The cap 11 has a shoulder 35 on its outer side against which the yoke 16 is adapted to bear in maintaining the injector within the cylinder walls. The cap 11 145 is provided with a dome portion 36 to form a chamber 41 adapted to receive the upper end of the sleeve 25 and permit the reciprocation thereof within the cap. The upper end of the cap 11 is provided with a sleeve portion 37 adapted to 150

slidingly receive a push rod 38 which bears against and serves to reciprocate the sleeve 25. Openings 39 and 40 may be provided in the cap 11 to permit air to pass freely into and out of the chamber 41 and to permit the upper portion of the injector to be oiled.

A pump plunger designated generally by the numeral 42 has, at its upper end, a threaded portion 43 which is inserted into the lower end of the sleeve 25. A collar 44 on the plunger 42 is arranged to bear against a shoulder 45 of the sleeve 25 to provide a close fitting joint between the plunger 42 and the sleeve 25.

The pump plunger 42, which will presently be more fully described, has cooperative engagement with a pump cylinder 46 which is inserted into the casing 10 through the lower end thereof. The pump cylinder has a central chamber 47 adapted to closely receive the plunger 42 so that any excessive amount of liquid is prevented from passing along the interface therebetween. The upper end of the cylinder 46 is arranged to closely fit the inner surface of the casing 10 as shown at 48, the junction therebetween being sufficiently close to prevent any substantial amount of liquid from passing therebetween. The lower end 49 of the pump cylinder 46 has, likewise, close engagement with the inner surface of the casing 10 and is provided with a flange 50 arranged to be held firmly against the lower end of the casing 10 by means of a holding nut 51 which also serves to support the nozzle tip, designated generally by the numeral 52, within the casing 10.

The holding nut 51 is provided with an internally threaded portion 53 arranged to cooperate with external threads 54 on the outer surface of the casing 10 near the lower end thereof and has slots 55 arranged to receive a spanner wrench or the like for removing a nut from the casing.

The nozzle 52, which may be of any conventional or desired design, is provided with an outlet 56 leading to orifices 56a providing a valve seat 57 and a chamber 58. At the upper end of the nozzle 52 is a sleeve-like portion 59 arranged to fit into the lower end of the pump cylinder 46. A collar 60 is formed on the nozzle intermediate the ends thereof and is arranged to be drawn tightly against the shoulder 50 by the holding nut 51 to secure the nozzle firmly within the casing 10.

In order to admit fuel into the pump chamber 47 the outer surface of the pump cylinder 46 and the opposing inner surface of the casing 10 are cut away to form the annular space 61. The pump cylinder 46 is prevented from rotation within the casing 10 by means of a locating screw 62 in the casing arranged to bear against a shoulder 63 on the cylinder, which projects into the annular space 61. Portholes 64 and 65 in the wall of the pump cylinder 46 permit fuel to pass from the annular space 61 to the chamber 47 when the pump plunger 42 is at the upper end of its stroke as shown in Fig. 2. The fuel enters the annular space 61 through a passageway 66 drilled in the wall of the casing 10 and closed at its lower end by a plug 66a. A fuel supply pipe 67 is arranged to have connection with the passageway 66 by means of bushings 68 and 69 which secure the end of the pipe 67 within the casing 10. Fuel is fed into the system by gravity or low pressure through the pipe 67, passing through the passageway 66 into the annular space 61. Since the space 61 is relatively large with respect to the amount fed at each stroke of the plunger, the fuel remains therein sufficiently long to permit the air

to separate out and collect in the upper portion of the space 61 or pass up into the passageway 66.

A valve stem 70 having a lower end 71 in contact with the seat 57 is axially and slidably positioned within the pump plunger 42. The upper end of the valve stem 70 is provided with a collar 72 against which the lower end of a loading spring 73 abuts.

The loading spring 73 is positioned within the sleeve 25 and is provided at its upper end with a mushroom head 74 arranged to abut against a head 75 threaded into the top of the sleeve 25. Pressure of the spring may be regulated to a certain extent by placing washers at either end thereof, against the collar 72 or the head 74.

Thus in the normal operation of the device liquid fuel will be delivered through the pipe 67 into the passage 66 through which it flows into the annular space 61. The fuel will flow from the space 66 through the portholes 64 and 65 into the chambers 47 and 58. If then the push rod 38 is forced downward forcing the sleeve 25 downward the pump plunger 47 will move downward closing off the portholes 64 and 65. When these holes are closed off further downward movement of the plunger 42 will cause pressure to be placed upon the fuel in the chambers 47 and 58. When this pressure reaches a predetermined amount, as determined by the pressure exerted on the valve stem 70 by the loading spring 73, pressure of the fuel on a shoulder 76 will cause the valve stem 70 to be moved upward, thus lifting the end 71 thereof from the seat 57. Fuel will then flow through the outlet 56 and orifices 56a and continue so long as the pressure on the fuel is sufficiently great to hold the valve stem in its open position.

Means are provided on the outer surface of the pump plunger 42 for relieving the pressure on the fuel in the chambers 47 and 58 when the pump plunger 42 has reached a predetermined point in its downward stroke. At this point pressure on the fuel is relieved permitting the plunger to continue its downward stroke without compressing the fuel in the chambers. This means is shown more in detail in Fig. 5 and consists of an annular groove on the outer surface of the plunger near the bottom end thereof, the development of which is shown in Fig. 6. The groove provides a portion 77 opening into the chamber 47 and a sloping edge 78 extending up to an annular portion 79. The length of the plunger stroke is constant. The lower edge of the plunger 42 controls the beginning and the sloping edge controls the end of the fuel delivery stroke. The amount of fuel to be injected is regulated by rotating the plunger 42 in a manner presently to be described. Thus the end of the delivery is reached sooner for a small quantity of fuel than for a large quantity. No fuel is injected into the combustion chamber when the groove portion 77 is in registration with one of the portholes 64 or 65. However, as the plunger 42 is rotated increasing amounts of fuel are injected up to the capacity of the pump. In the uppermost position of the plunger, the two opposite ports 64 and 65 are open and the pump chamber 47 is filled with fuel. Delivery begins as soon as the plunger has covered the ports on the way down and ends as soon as the sloping edge 78 of the groove opens the port 65 and permits the fuel to escape from the pump chamber 47 through the groove portion 77 in the plunger and the port 65 into the annular space 61. Downward movement of the plunger 42 continues, however, until the annular groove portion 79 comes

into registration with the portholes 64 and 65. In this position any air which may have become entrapped in the groove 79 is permitted to pass out through the portholes into the annular space 61. The air may pass upward from the annular space 61 through the passageway 66 into the fuel supply pipe 67 from which it may be relieved by any desired or well known method.

Referring now to Figs. 2 and 7 the plunger 42 is rotated through lateral movement of a rack 80 supported in a sleeve 81 of the casing 10 and arranged to engage the feathered pinion 28 as shown in Fig. 7. The racks of adjoining cylinders may be connected together by means of links 82 and 83 connected to the racks by means of pins 84 and 85 passing through openings 86 and 87 at opposite ends of each of the racks, whereby the amount of fuel injected into each of the cylinders may be uniformly controlled. In order to indicate to the operator the position of the rack 80 and the corresponding position of the groove portions 77, 78 and 79 with respect to the porthole 65, an opening 88 is provided in the sleeve 81 having an indicating mark 89 or other device cooperable with a scale 90 on the rack 80. The operator may thus know by glancing at the scale, visible through the opening 88, the amount of fuel being fed into the cylinder.

Operation of the plunger 42 within the cylinder 46 will, because of the relatively high pressure, result in a certain amount of the fuel passing along the interface of these members into the opening 24 around the sleeve 25. Since the fuel will normally be an oil having a certain amount of lubricating properties this leakage is employed to lubricate the lower working parts of the device. In order, however, to remove the excess of oil moving upward in this manner a drain line 91 is secured in an opening 92 by means of bushings 93 and 94 of conventional design, in the side of the casing 10 which has communication with the central opening 24. Holes 95 are provided in the sleeve 25 to permit the escape of the liquid from the interior of the sleeve.

The push rod 38 must be actuated in timed relation with the movement of the engine cylinder. This may be accomplished in any well known way, as for example, by an over-head cam shaft wherein the cams are actually brought in contact with the push rod 38. Such a construction, however, makes the removal of the injector from the cylinder rather difficult and I have, therefore, shown in the accompanying drawings a rocker arm designated generally by 96 which is arranged to be supported upon a suitable bearing 97. The rocker arm 96 is arranged to have one end 98 thereof project over the push rod 38, the end 98 being provided with an adjusting screw 99 arranged to bear against the upper end of the push rod 38. The opposite end of the rocker arm 96 is provided with a socket 100 arranged to receive a cam rod 101, the latter being arranged to be reciprocated by a cam on a conventional cam shaft as will be obvious.

The advantages of my improved construction will be obvious to those skilled in the art. There are no fuel lines or pipes in which the fuel is maintained under pressure or is placed under pressure with each stroke of the pump, and consequently there is no opportunity for oscillations to be set up in the lines, to interfere with the accuracy of the injection.

The volume under compression is so small that the pressure is built up in the pump chamber 47

almost instantaneously and therefore, the difference in lag in the injection caused by variations in speed and load are almost completely eliminated. This means that the engine will be timed uniformly regardless of the quantity of fuel being injected.

In like manner the amount of fuel actually placed under pressure at each stroke of the pump is reduced to an absolute minimum whereby the operation of the injector is brought to a maximum of accuracy.

The injector nozzle and the fuel pump are incorporated in a single unitary structure whereby the space occupied is reduced to a minimum and the duplication of parts involved in the manufacture of separate pumps and injection nozzles is eliminated.

The lower end of the injector in contact with the fuel is designed to be entirely self-lubricating.

It will be seen that by completely eliminating the pressure on the fuel pipes the cost and difficulty of maintaining the fuel supply system in repair is substantially reduced because of the reduction in the tendency for the system to leak fuel.

It will be seen that because of the design of my improved injector a Diesel engine may be made to operate smoothly at great variations in speed and load without resorting to specially manually operated devices for reducing and increasing the injection pressure. With the ordinary system, if the valve opening pressure is set quite high the motor operates well under a high load and the fuel consumption is relatively low but under these conditions the motor will not idle well, for reasons already disclosed. Because of this, special manually operated devices are provided for reducing the pressure on the loading spring. Examination of my improved construction will show, however, that when the plunger 42 is rotated to a point where only a small amount of fuel is to be injected, injection begins when the plunger 42 has barely begun its downward stroke. Under these conditions the loading spring 73 is only slightly compressed when the valve stem 70 is lifted. The plunger 42 will have proceeded downward only a small distance when the sloping edge 78 of the groove comes in contact with the porthole 65 and the pressure is released in the pump chamber 47. Because of the small downward movement of the plunger the pressure on the spring will not have been materially increased and is consequently quite low when the pressure is relieved. On the other hand, when the plunger 42 is rotated to a point where the maximum amount of fuel is being injected downward movement of the plunger causes the stem 70 to be lifted at the same pressure, but as the plunger 42 continues downward the pressure on the valve stem 70 increases and, since the plunger 42 continues almost to the bottom of its stroke before the pressure on the fuel is relieved and the compression on the spring materially increases, the pressure on the fuel required to maintain the valve 70 in an open position is materially greater. It will, therefore, be plain that as the amount of fuel being injected is increased the ultimate pressure on the fuel in the pump chamber 47 is increased. Clearly this is almost an ideal condition, since the first fuel injected into the combustion chamber enters under a small pressure and burns immediately adjacent to the nozzle. As the injection proceeds the pressure with which the fuel is forced into

the combustion chamber increases, thus causing the newly entering fuel to be sprayed outward beyond the area within which the preceding fuel has burned. Therefore, when the motor is idling or under light load, and only a small amount of fuel is being injected, it is injected under a low pressure and when the load increases and more fuel is injected the valve closing pressure is automatically increased. It will further be seen that when the plunger 42 has moved down sufficiently far to bring the porthole 65 in coincidence with the groove, considerable pressure has been built up on the valve stem 70 by compression of the loading spring. Under these circumstances the sudden relieving of the pressure in the pump chamber 47 causes the valve stem 70 to be forced down very rapidly against the seat 57, whereby after drip is substantially eliminated.

It will be understood that the injector may also be used with explosion engines, such as gasoline engines in which the charge is exploded by means of a spark, and I do not intend to restrict the use of the device to Diesel engines. Though it is primarily designed for use therewith, it may be used under suitable circumstances with any type of internal combustion engine.

While I have thus described and illustrated a specific embodiment of my invention I am aware that numerous alterations and changes may be made therein without materially departing from the spirit of the invention and I do not wish to be limited except as required by the prior art and the scope of the appended claims.

I claim:

1. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder wall of said engine, a sleeve slidably positioned within said casing, a pump plunger secured to said sleeve, a pump cylinder positioned in said casing and arranged to cooperate with said plunger to provide a pump chamber, an injection orifice connecting said pump chamber with a combustion chamber of said engine, a valve stem arranged to normally close said orifice, said pump plunger being arranged to be reciprocated at timed intervals to place a pressure upon liquid fuel in said pump chamber and force said fuel through said orifice into said combustion chamber, means acting between said plunger and said valve stem, arranged to progressively increase the pressure on said valve stem when said pump plunger moves downward in an injection stroke, whereby the pressure on the fuel in said pump chamber required to maintain said valve in an open position is progressively increased, means on said pump plunger adapted to vary the amount of fuel injected into said chamber by rotation of said plunger, means for manually rotating said plunger, and means for supplying fuel to said combustion chamber.

2. In an injector for Diesel engines adapted to inject fuel into a combustion chamber thereof, a tubular casing, a pump cylinder positioned within said casing near the lower end thereof, said pump cylinder having a chamber and fuel port thereto, a nozzle tip secured in said casing providing an injection orifice between said pump chamber and said combustion chamber, a valve stem axially positioned within said casing having a lower end positioned over said orifice arranged to normally close the same and be hydraulically lifted, a plunger surrounding said valve stem and arranged to reciprocate within said pump chamber to close said port and place a pressure on the

fuel in said pump chamber and force it through said orifice, said plunger having port opening grooves for relieving the pressure on said fuel, a sleeve reciprocable within said casing fixedly secured to said plunger, a loading spring abutting at one end against said valve stem and at the other end against said sleeve, a means to adjust the position of said groove with respect to said port and thereby regulate the amount of fuel to be injected into said combustion chamber, means for supplying fuel to said fuel port, means for moving said plunger downward in an injection stroke at timed intervals, whereby pressure is placed on the fuel in said pump chamber, thereby lifting said valve stem and permitting fuel to be injected into said combustion chamber, downward movement of said sleeve causing the pressure on said spring to be increased to increase the pressure on the fuel entering said combustion chamber, said grooves and port releasing the pressure on said fuel when a predetermined amount of fuel has passed through said orifice, whereby said valve stem is seated under said increased load to prevent drip into said combustion chamber from said orifice.

3. The combination in an injector for internal combustion engines of an injector casing having a measuring chamber and an injection orifice substantially at one end thereof, means within the measuring chamber substantially at said orifice for forcing a measured quantity of fuel therethrough, and means acting upon said means for varying the quantity of fuel injected.

4. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of an engine having a pump chamber at the inner end thereof and an injection orifice connecting said chamber with a combustion chamber of said engine, a uniform stroke pump plunger for forcing fuel through said orifice, and means for varying the amount of fuel injected with the angular position of the plunger.

5. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of an engine having an injection orifice at the inner end, a pump cylinder adjacent the injection orifice and an opening for the reception of fuel, a pump plunger in said cylinder arranged to cut off the fuel supply opening substantially at said cylinder as said plunger starts the injection stroke to determine the start of injection, valve means for opening and closing said orifice for the passage of fuel therethrough, and means for by-passing varying amounts of the fuel in said chamber depending upon the rotative position of said plunger.

6. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of an engine having an injection orifice at the inner end, a pump cylinder, a fuel supply opening, a plunger in the cylinder arranged to cut off the fuel supply opening substantially at said cylinder to determine the start of injection, means for by-passing the excess fuel in said cylinder toward the end of the stroke, and means to regulate the point in the plunger stroke at which by-passing begins, to regulate the amount of fuel injected.

7. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of an engine having a pump chamber at the inner end thereof, an injection orifice connecting said chamber to a combustion chamber of said engine, and at least one port for supplying fuel to said pump chamber, a re-

reciprocable plunger arranged to close said port to determine the start of injection and having passages for connecting said ports and said chamber, after commencement of injection, and means
5 for setting said plunger to open said ports upon the passage of a predetermined amount of fuel through said orifice.

8. The combination in an injector for Diesel engines, of a cylinder removably positioned in the
10 cylinder walls of an engine having a port for the reception of fuel and a fuel injection orifice, a reciprocable plunger in said cylinder arranged to close said port to apply pressure to fuel in
15 said cylinder, said plunger having a channel provided with a helical side, and a needle valve for said orifice arranged to be opened in response to pressure on said fuel, said channel serving to
20 open said port at a predetermined position in the reciprocation of said plunger to relieve the pressure on said fuel to cause said valve to close sharply.

9. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of said engine and having a
25 pump chamber at the inner end thereof, and an injection orifice connecting said chamber to a combustion chamber of said engine, a plunger therefor, means to impart a stroke to said plunger of uniform length regardless of load and
30 speed to force fuel through said orifice, and means in said chamber for stopping injection when said plunger reaches a predetermined point in its stroke.

10. The combination in an injector of the character described of a cylinder arranged to be
35 positioned in the walls of an engine and having an injection orifice opening into the combustion chamber thereof, a piston in said cylinder movable to inject fuel into the combustion chamber
40 of an engine through said orifice, means for supplying fuel to said cylinder, the latter having a port for the reception thereof, said piston having means for closing said port during a portion of
45 its travel and for opening said port at a predetermined time in its travel to relieve the pressure on said fuel and terminate said injection.

11. The combination in an injector for Diesel engines, of a casing adapted to be secured in the cylinder wall of said engine, having a fuel measuring chamber and an injection orifice at the
50 inner end thereof communicating with a combustion chamber of the engine, a valve arranged to normally close said orifice and be opened by a predetermined amount of hydraulic pressure, a pump plunger actuated at timed
55 intervals arranged to compress a quantity of liquid fuel whereby said orifice is opened, means for conducting fuel from the exterior of said casing to said chamber to be acted upon by said plunger, and means located substantially at the junction
60 of said last mentioned means and said chamber for quickly relieving the pressure on said fuel when a predetermined amount thereof has passed through said orifice whereby to close said valve against low pressure to cut off the injection sharply.

12. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of an engine having a pump
65 chamber at one end thereof and an injection orifice connecting said chamber with a combustion chamber of the engine, valve means for opening and closing said orifice for the passage of fuel therethrough, a uniform stroke pump
70 plunger for forcing fuel through said orifice, and

means within said pump chamber for placing and releasing pressure on the fuel upon reciprocation of the plunger.

13. The combination in an injector for internal combustion engines, of a casing adapted to
80 project into the combustion chamber of the engine having a pump chamber for fuel and an injection orifice connecting said chamber with said combustion chamber a port in said casing
85 arranged to terminate the injection upon being uncovered, hydraulic valve means for closing said orifice arranged to open at a predetermined pressure on the fuel, a uniform stroke pump
90 plunger in the chamber for applying pressure to the fuel and forcing fuel through said orifice, and means movable with the plunger for uncovering the port and relieving the injection pressure on the fuel at any predetermined point in the stroke
95 of the plunger to relieve the injection pressure on said fuel and close said valve to stop injection.

14. The combination in an injector for internal combustion engines, of a casing adapted to be positioned in the cylinder walls of an engine having a pump cylinder at one end thereof, a
100 fuel supply opening thereto, and an injection orifice, a plunger in the cylinder arranged to cut off the fuel supply opening substantially at said cylinder as the plunger starts the injection stroke, hydraulic valve means closing said orifice
105 opened at a predetermined pressure on the fuel, means for by-passing through said fuel supply port the excess of fuel in said cylinder toward the end of the stroke to relieve the injection pressure on said fuel and close said valve against
110 low pressure, and means to regulate the point in the plunger stroke at which by-passing begins, to regulate the amount of fuel injected.

15. In an injector for Diesel engines for injecting fuel into a combustion chamber thereof, a casing adapted to be positioned in the cylinder
115 wall of an engine, and having an injection orifice opening into said combustion chamber, a pressure operated valve normally closing the orifice, a pump in said casing in close proximity to said
120 orifice arranged to inject fuel into said combustion chamber through said orifice, having an annular space between said pump and said casing provided with openings to permit fuel to enter
125 said pump from said space, means in said pump for closing said openings at a fixed point in the downward stroke thereof and for opening said openings at a variable point in said downward stroke to regulate the amount of fuel injected, and means for supplying fuel to said annular
130 space.

16. In a combined fuel pump and injection nozzle, a casing having a small capacity fuel chamber in close proximity to the inner end
135 thereof, and an injection orifice connecting said chamber with the combustion chamber of an engine, the capacity of said fuel chamber being but slightly greater than the maximum volume of fuel to be injected at any one time, pressure actuated valve means closing said orifice, and a
140 plunger arranged to intermittently decrease the volume of said chamber to place pressure on the fuel therein and force it through said orifice, said plunger having means for by-passing fuel when a predetermined amount has been injected.
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17. The combination in a liquid fuel injector for Diesel engines, of an injector casing adapted to be positioned in the cylinder walls of an engine and having an injection orifice at its inner end
150 communicating with the combustion chamber of

- the engine, a small capacity chamber in close proximity to said orifice of capacity but slightly greater than the maximum volume of fuel to be injected at any one time, said chamber having 5 ports for the reception of fuel, a plunger arranged to intermittently decrease the volume of said chamber by a constant amount and close said ports, to place pressure on the fuel therein and force it through said orifice, said plunger being 10 provided with by-pass means for by-passing fuel when a predetermined amount has been injected to stop injection, a valve normally closing said orifice arranged to open when the pressure on said fuel reaches a predetermined point, and 15 automatic means for progressively increasing the injection pressure on said fuel as the volume of said chamber decreases, whereby the velocity of the fuel passing through said orifice is progressively increased.
- 20 18. An injector for internal combustion engines comprising a casing adapted to be positioned in the cylinder walls of an engine having an injection orifice, and a reciprocable plunger in said casing having adjustable measuring 25 means near the end thereof in close proximity to said orifice for forcing a measured quantity of fuel through the orifice.
19. The combination in a combined pump and injection nozzle for Diesel engines of a cylinder 30 removably positioned in the cylinder walls of an engine having a port for the reception of fuel and a fuel injection orifice, a plunger for said cylinder having a channel provided with a helical side, said port being closed by said plunger 35 at the beginning of its stroke to start injection, and opened during the stroke by coincidence with said channel to stop injection, means for actuating said plunger, and means for rotating said plunger about its axis whereby to vary the length of said plunger stroke through which said port is closed to vary the amount of fuel injected. 80
20. The combination in an injector for Diesel engines, of a casing adapted to be positioned in the cylinder walls of an engine having an injection orifice at one end of the casing and a fuel 85 supply port, a plunger reciprocable in the casing to inject a measured quantity of fuel into the combustion chamber of said engine through said orifice, and means arranged through relative rotation of said plunger and said supply port to alter the amount of fuel injected. 90
21. In an injector of the class described, a casing projecting into the combustion chamber of an engine, an injection orifice at one end of the casing, a plunger in the casing operative in injecting 95 fuel into said combustion chamber through the orifice, and means for metering the fuel including a by-pass passage on the plunger arranged to by-pass the fuel when the latter has moved a predetermined amount.
22. In an injector for internal combustion engines 100 having a casing and an injection orifice, pressure actuated valve means closing the orifice, a reciprocable plunger in said casing in close proximity to said orifice for forcing fuel through said orifice, a port in said casing arranged to 105 terminate the injection upon being uncovered, and means movable with said plunger for uncovering said port, adjustable by rotation to vary the amount of fuel injected.
- FREDERICK RITZ. 110

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