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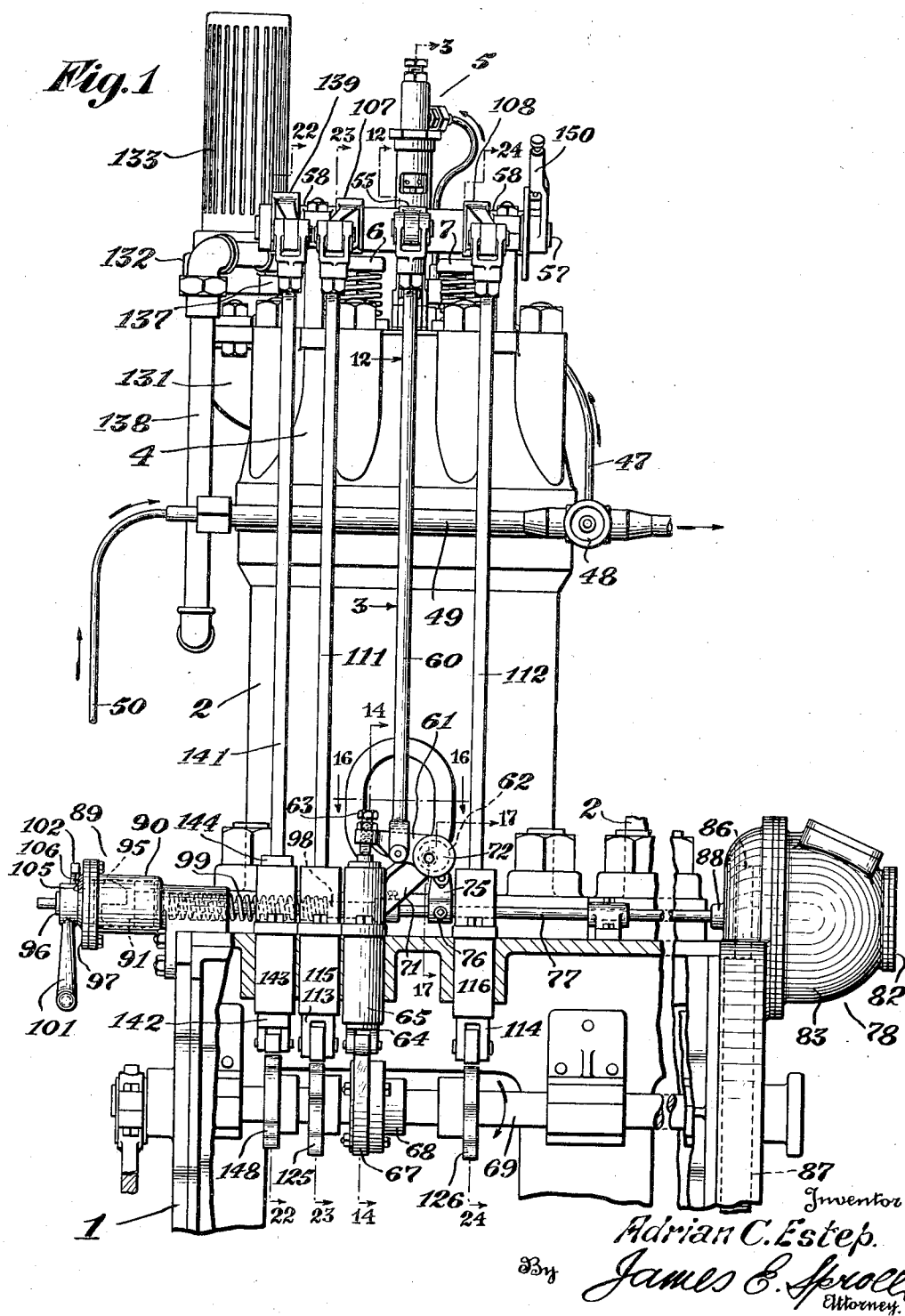
A. C. ESTEP

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FUEL INJECTION VALVE

Filed Jan. 22, 1926

4 Sheets-Sheet 1



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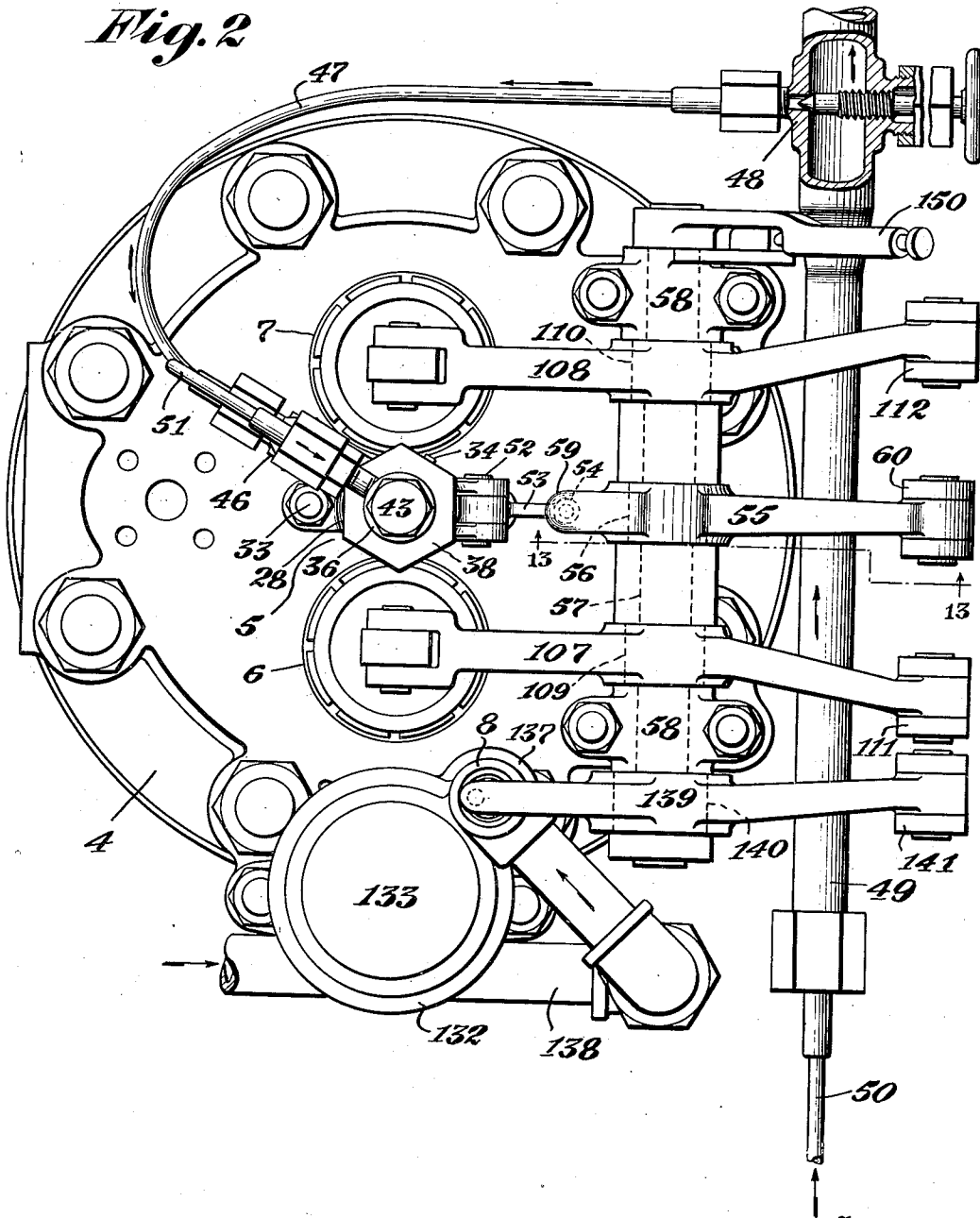
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Filed Jan. 22, 1926

4 Sheets-Sheet 2

Fig. 2



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Jan. 6, 1931.

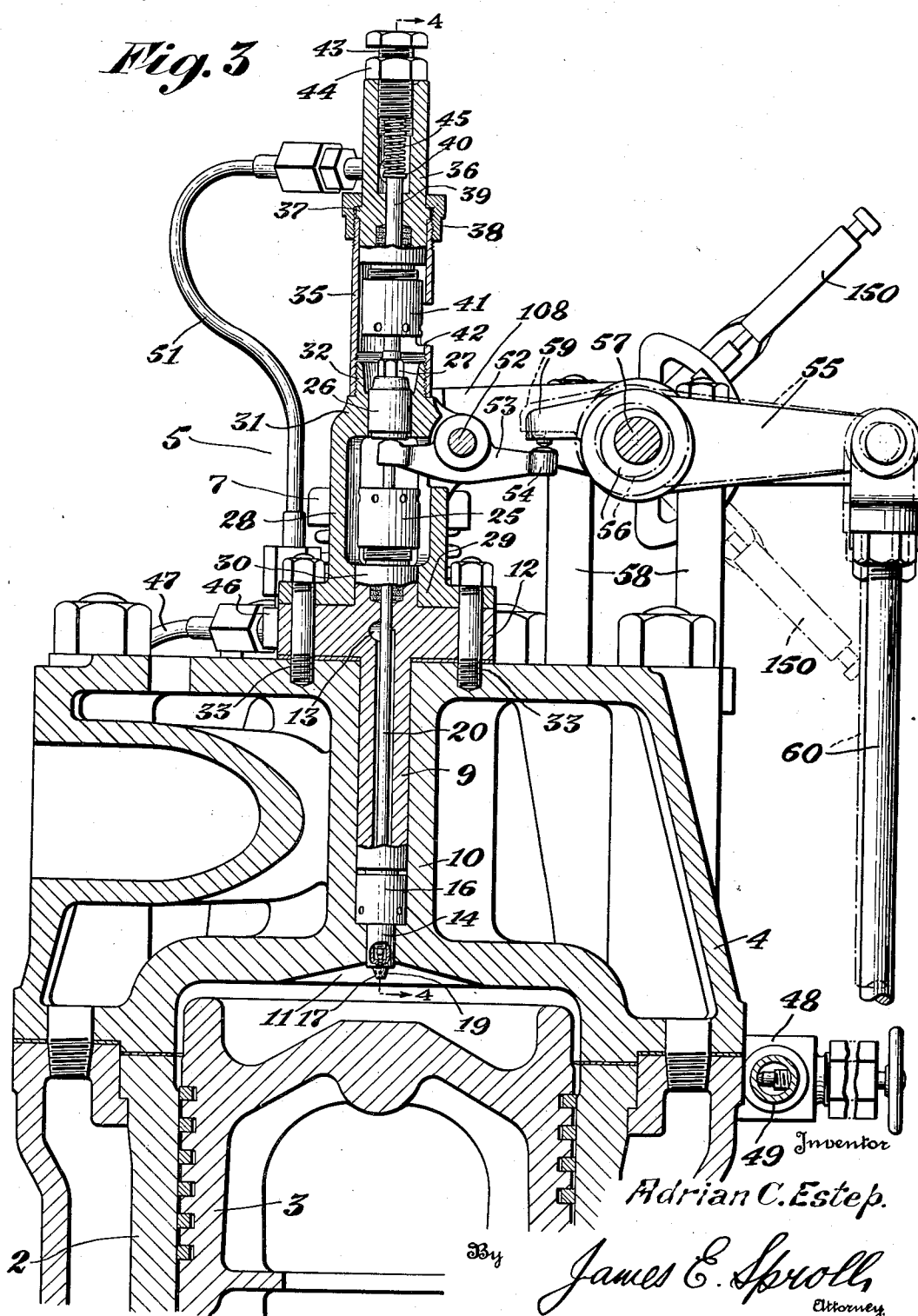
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FUEL INJECTION VALVE

Filed Jan. 22, 1926

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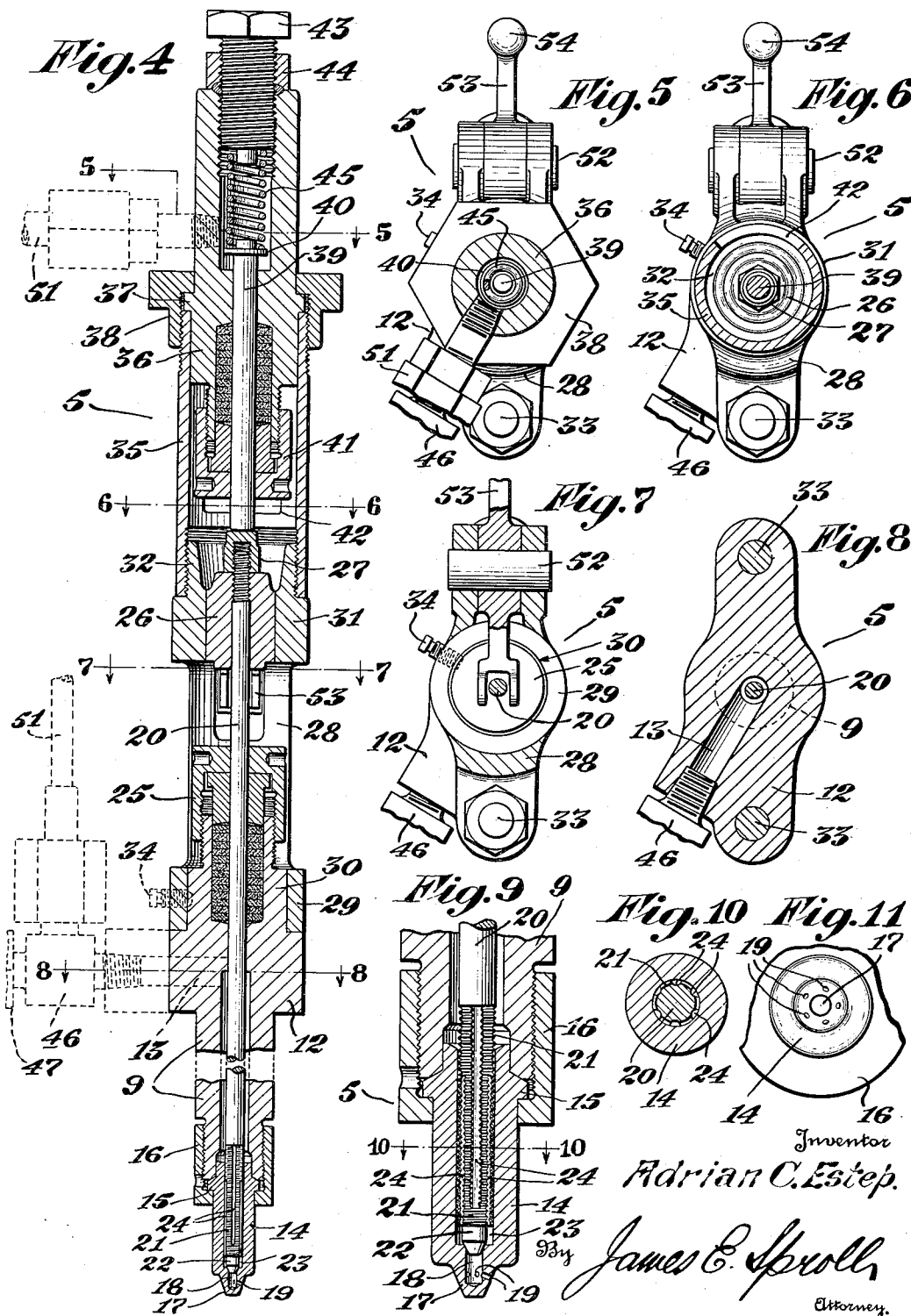
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Filed Jan. 22, 1926

4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

ADRIAN C. ESTEP, OF SEATTLE, WASHINGTON

FUEL-INJECTION VALVE

Application filed January 22, 1926. Serial No. 82,951.

This invention is an improvement in fuel injection valves for injecting and spraying under high pressure heavy or tarry fluid fuels within the combustion spaces of high compression internal combustion engines, and the primary objects of the improvement is the provision of a cam actuated governor regulated and controlled fuel injection valve, especially designed to strain the fluid fuel driven therethrough prior to and immediately preceding the metered and timed injection and spraying of the same within and throughout the combustion space of the correlated engine cylinder, to materially improve the fineness and uniformity of fluid fuel distribution, to promote and accelerate the rapidity of fluid fuel introduction, atomization and combustion, and to materially increase the thermal efficiency, economical operation and reliability of the associated engine.

With these ends in view the invention essentially resides in the provision of an overbalanced fuel injection valve, for a high compression internal combustion engine, and in the preferred embodiment thereof is characterized by the employment of a readily accessible and removable nozzle having a valve seat and a series of downwardly directed radial discharge orifices formed therein; of a valve stem or needle valve having an integral fluid fuel strainer fitting and seating within said nozzle, whereby and whereat foreign matter or particles carried in suspension by the fluid fuel is intercepted prior to and immediately preceding the ejection and spraying of the same through the nozzle discharge orifices, when the valve stem is lifted or unseated; of novel anti-friction guide means for the upper end of the valve stem exteriorly of the correlated stuffing box thereof, whereby side friction of the valve stem therein is reduced and effectively minimized during actuation of the same there-through; of a correlated overbalance body removably secured to the upper end of the fuel injection valve having free and uninterrupted communication with the injection valve fluid fuel supply conduit and fitted with a fluid pressure actuated overbalance stem of slightly larger diameter than the injection valve stem, with which it abuts to overbalance and provide a surplus pressure thereon, to thereby seal the same upon the seat thereof except when said injection valve stem is mechanically lifted or unseated; of spring or auxiliary resilient means for the pressure actuated overbalance stem, whereby the friction of the several working parts of the valve is overcome when starting the correlated engine at extremely low pressures, there being insufficient overbalance pressure at such times to overcome said friction, although the ratio of overbalance is the same at all pressures except for the slight pressure exerted by said spring means; and of novel actuating and controlling mechanisms interposed between the valve and the engine governor and cam shaft, whereby the injection and spraying of fluid fuel are regulated as to time of occurrence and quantity and the lift of the valve stem is adjustably regulated and predeterminedly controlled by action of the engine governor, which latter is not subjected to or affected by excessive loads, when the correlated engine thereof is operating at lower than normal injection pressures.

The invention further resides in the novel construction, combination, adaptation, and arrangement of parts, as will hereinafter be more fully described and succinctly defined in the claims appended hereto.

Referring now to the accompanying drawings, wherein is illustrated the preferred embodiment of the invention.

Figure 1 is a side elevation of an internal combustion engine equipped with a fuel injection valve and the appurtenant actuating and controlling mechanism thereof fabricated in accordance with the invention, certain parts being shown in section and certain other parts omitted for clarity of illustration.

Fig. 2 is a top plan view of the same, with certain parts in section.

Fig. 3 is a central transverse vertical section of the valve and correlated cylinder head structure thereof taken through 3—3 of Fig. 1, illustrating certain valve parts in eleva-

tion and the valve partially opened to correspond to the relative position of the associated engine piston shown at or about compression dead center.

Fig. 4 is an enlarged fragmentary vertical section of the valve taken through 4—4 of Fig. 3, as it would appear when removed from the correlated cylinder head structure thereof.

Figs. 5, 6, 7 and 8, are horizontal sections taken through 5—5; 6—6; 7—7 and 8—8, respectively, of Fig. 4.

Fig. 9 is an enlarged fragmentary vertical section of the nozzle end of the valve.

Fig. 10 is a horizontal section taken through 10—10 of Fig. 9.

Fig. 11 is a fragmentary inverted plan of the valve nozzle.

It is well known by those skilled in the art of fabricating and operating Diesel engines, that the practicability and efficiency of the same depend largely upon the construction and operation of the atomizing or spraying device employed to introduce or inject the fluid fuel within the engine cylinder or cylinders, complete or perfect combustion being necessary and essential in order to obtain the highest efficiency, and to secure such a degree of combustion it is of the utmost importance to break up or pulverize the molecules of fluid fuel and inject the same into the engine cylinder in the form of a finely divided spray, in which form it has the greatest efficiency since a more perfect combustion results, and it is with the foregoing in view that the fuel injection valve about to be described has been provided.

In the drawings and description similar reference characters designate similar parts throughout the several views.

The numeral 1 designates an engine crank case whereon a water-jacketed engine cylinder, or cylinders, 2 are rigidly secured, each having a piston 3 fitted for reciprocation therein, the upper end of which is recessed and obtusely coned, and at top dead center projects within the concentrically recessed lower end of a water-jacketed cylinder head structure 4 suitably secured or bolted in axial alignment upon the upper end of the engine cylinder 2, whereat the said recessed lower end in conjunction with the recessed upper end of the piston 3 periodically serve or function as a combustion space or chamber, for said engine cylinder.

Mounted upon and embodied within the cylinder head structure 4 is the valve controlling system of the engine cylinder 2, comprising a concentrically mounted fuel injection valve 5, of the overbalanced type, an air inlet valve 6, an exhaust valve 7, a starting air timing valve 8 interconnected with the combustion air intake passage of the air inlet valve 6, and the several appurtenant actuating mechanisms therefore.

In the preferred embodiment the fuel injection valve 5 is designed to meter and time the injection or spraying of the fluid fuel within and throughout the combustion chamber of the engine cylinder 2, and to strain or filter such fluid fuel prior to and immediately preceding said injection or spraying thereof, and for this purpose is provided with a cylindrical or tubular valve body 9 adapted to snugly fit and to be removably mounted within the upper or larger bore of an axially aligned integral housing 10, of the cylinder head structure 4, said housing having an interior bore of two diameters, the lower or smaller of which terminates at the lower end in a downwardly flaring axially aligned recess 11, formed within the lower wall of said cylinder head structure, and opening into the combustion space of said engine cylinder.

The valve body adjacent the upper or inlet end thereof is provided with an integral flange 12 adapted to abut and to be removably secured to the upper face of the cylinder head structure 4, said flange having a fluid fuel inlet passageway 13 formed therein communicating at the inner end with the central bore or interior of said valve body.

The lower or outlet end of the valve body 9 is exteriorly reduced and threaded and is interiorly enlarged to receive the upper end of a readily removable tubular nozzle 14 adapted to snugly fit therein, and provided thereat with an annular bevelled shoulder or collar 15 designed to normally seat within the correspondingly shaped terminal face of said valve body, and to be normally maintained therein by a cylindrical retaining or union nut 16 threadably engaged upon the exteriorly reduced and threaded lower end thereof.

The valve body 9 and correlated nut 16 fit snugly within the upper or larger interior bore of the housing 10, while the nozzle 14 extends downwardly therefrom in axial prolongation thereto, to snugly fit within the lower or smaller interior bore of said housing 10, and to extend therethrough, whereby the lower terminal, or tip, of said nozzle projects within the downwardly flaring recess 11.

The nozzle 14 is provided with an interior bore of two diameters, and at the lower end thereof with a downwardly extending frustoconical tip 17 having the lower or smaller of said bores formed therein and constituting thereat a fuel discharging or outlet chamber 18, the walls of which are provided preferably with a plurality of radially and downwardly directed discharge orifices 19 leading to the combustion space of the engine cylinder 2.

The numeral 20 designates a mechanically actuated valve stem, or needle valve, for periodically admitting a charge of fluid fuel into the engine cylinder 2, said valve stem being mounted for axial movement within the

valve body 9, and having an integral fluid fuel strainer 21 formed thereon adjacent the lower end thereof designed to snugly fit within the upper or larger bore of the nozzle 14, and provided upon the extremity thereof with a cylindrical portion 22 of reduced diameter, the hardened terminal of which is tapered or bevelled to fit and seat within a correspondingly shaped and hardened face or seat formed within the nozzle 14, at the juncture of the bores thereof. The cylindrical portion 22 in conjunction with the lower end of the larger bore of the nozzle 14 serves and functions to form and constitute thereat an annular fuel collecting chamber 23.

The integral fluid fuel strainer 21 is formed upon the valve stem 20 by exteriorly threading a portion of the same adjacent the lower end, and cutting a series of longitudinal grooves 24 therein, said grooves being interconnected by the relatively fine threads thereof, alternate grooves of said series communicating at their upper ends with the interior bore of the valve body 9, and the other grooves of said series communicating at their lower ends with the fuel collecting chamber 23.

By forming the integral fluid fuel strainer 21 upon the lower end of the valve stem 20 and fitting the same snugly within the nozzle 14, all as herein shown and described, the fluid fuel driven therethrough is strained thereby, to intercept thereat any foreign matter or particles held in suspension in said fluid fuel, prior to and immediately preceding the ejection and spraying of the same through the discharge orifices 19 during the periodic unseating of said valve stem, and by disposing the nozzle tip 17 within the downwardly flaring recess 11, as shown and described, the spray fluid fuel emerging from the orifices 19 is deflected downwardly thereby into the combustion space of the engine cylinder 2 in the form of a coneshaped atomized spray, thus assuring of a uniform atomization and distribution of fluid fuel, of the desired density and fineness, within and throughout the said combustion space. Also by fabricating the nozzle 14 and attaching the same to the valve body 9 in the manner herein disclosed, said nozzle 14, when the valve body 9 is withdrawn from the correlated housing 10, is rendered readily accessible and removable for cleaning, repairs and replacement.

The numeral 25 designates a stuffing box provided upon the upper end of the valve body 9 for the mechanically actuated valve stem 20, said stem extending upwardly there-through and provided adjacent the upper end thereof with a crosshead or cylindrical guide 26 threadably engaged thereon and retained against axial dislodgment therefrom, by a cap or lock nut 27 similarly engaged upon the upper terminal of said valve stem.

Concentrically mounted upon the upper end of the valve body 9 is a vertically disposed

yoke or casing 28 designed to partially surround or enclose the stuffing box 25 and having an integral annular boss 29 at the lower end to receive and snugly fit upon an enlarged cylindrical portion 30 of the said valve body and provided at the upper end thereof with an integral annular guide or boss 31, wherein the cross head 26 is slidably mounted, said annular guide having an interiorly enlarged and exteriorly reduced threaded portion 32 extending upwardly thereupon in axial prolongation thereto.

The lower end of the yoke 28 and the flange 12 of the valve body 9 are conjointly and removably secured to the upper end of the cylinder head structure 4, by stud bolts 33, and the yoke 28 is retained in fixed relation upon the valve body 9, when the latter is removed from the said cylinder head structure 4, by a set screw 34 threadably engaged within the wall of the annular boss 29 and normally seating within the cylindrical wall of the portion 30, as shown more clearly in Figs. 4 and 7.

By providing the upper end of the valve stem 20 with the crosshead 26 and slidably mounting the latter in the annular guide 31 of the yoke 28, such construction functions as a guide and anti-friction mechanism for the said valve stem 20, and thereby materially reduces side friction of the same within the correlated stuffing box 25 thereof, as will be manifest and apparent.

A tubular or cylindrical casing 35 interiorly threaded at the lower end is mounted thereat upon the exteriorly reduced and threaded portion 32 of the yoke 28 and extends upwardly therefrom in axial alignment thereto, said casing having the lower end of a cylindrical over-balance body 36 snugly fitting within the upper exteriorly threaded end thereof, which body extends upwardly therefrom in axial prolongation thereto.

The lower end of the over-balance body 36 is normally retained in snugly fitting relation within the exteriorly threaded upper end of the casing 35, and for this purpose is provided exteriorly and substantially midway the length thereof with an integral annular collar or shoulder 37, which normally abuts the upper end of said casing and is maintained in abutting relation thereon by a union nut 38.

A fluid pressure actuated over-balance stem 39, preferably of a slightly larger diameter than the mechanically actuated valve stem 20, is concentrically mounted for sliding movement within the lower or enclosed portion of the body 36, and at the lower end normally abuts the cap nut 27 of said valve stem 20, while the upper end of said over-balance stem 39 projects within the interior bore of said body 36, and is provided thereat with a washer or annular disk 40 rigidly secured thereto, and of a slightly lesser diameter than that of

the said interior bore, to thereby eliminate friction therebetween.

A stuffing box 41 for the over-balance stem 39 is provided upon the lower end of the body 36 enclosed by the casing 35, and such stuffing box 41 is rendered readily accessible for adjustment therein by an opening or aperture 42 formed within the cylindrical walls of the casing 35.

The interior bore of the body 36 is threaded at the upper end to receive an adjusting screw 43, which latter is maintained in a selected adjusted position within said interior bore, by a lock nut 44.

Interposed between the washer 40 and the inner end of the adjusting screw 43 is a relatively light helical compression spring 45, the function of which is to overcome the friction of the working parts of the fuel injection valve and to retain the valve stem 20 upon the seat thereof, so that said valve stem will be sealed thereon at all times, except when mechanically lifted or actuated to inject and spray the fluid fuel within the combustion space of the engine cylinder 2. Compression of the spring 45 may be varied by adjusting the screw 43, as will be readily apparent and manifest.

The pressure actuated over-balance stem 39 is formed of slightly larger diameter than the valve stem 20 and the contiguous ends of said stems are maintained in normally abutting and axially aligned relation in the manner herein shown and described, in order that the over-balance stem 39 may overbalance and provide a surplus pressure upon the valve stem 20, and in conjunction with the compression spring 45 retain and seal the said valve stem 20 upon the seat thereof, the ratio of overbalance is the same at all working pressures except for the slight pressure exerted by the said compression spring 45, which latter is necessary and essential when starting at extremely low pressures, there being insufficient overbalance pressure of fluid fuel to overcome friction of working parts.

The fluid fuel inlet passageway 13 of the main valve body 9 is connected by a three-way fitting or T 46 to a fluid fuel supply conduit 47, which latter is connected at the outer end to a needle valve 48 interposed within a fluid fuel manifold 49, of the correlated engine, said manifold receiving fluid fuel under high pressure from a common delivery conduit 50 connected at the intake end thereof to a fluid fuel pump, not shown.

A conduit 51 connects the three-way fitting 46 with the interior bore of the over-balance body 36, whereby free and uninterrupted communication is established and maintained between the fluid fuel inlet passageway 13 and said interior bore. Manifestly, therefore, with fluid fuel pressure continuously maintained in the inlet passageway 13, such fluid fuel pressure is similarly maintained in

the interior bore of the balance body 36, wherein it exerts a downwardly directed pressure upon the over-balance stem 39, which pressure is imparted thereby to the valve stem 20 and serves to retain the latter upon the seat thereof except when mechanically actuated or lifted.

Fulcrumed, as at 52, upon the yoke member 28 is a stem actuating or lifting rocker arm 53, the inner bifurcated end of which projects within said yoke member to straddle the valve stem 20 and normally abut the correlated crosshead 26 thereof, whereat the said valve stem is actuated or lifted by the oscillations of said rocker arm.

The air starting mechanism of the engine and the valve actuating and controlling mechanism herein partly shown do not form part of the subject matter of the present application except as the same or equivalent devices may be employed in co-operative association and combination with other parts of the valve controlling system, the subject matter of the air starting mechanism, per se, being fully shown and described in my separate co-pending application; filed August 14, 1924; Serial No. 731,953; and the subject matter of the valve actuating and controlling mechanism, per se, being similarly disclosed in my co-pending application therefor; filed January 27, 1926; Serial No. 84,005.

So far as I am aware I am the first to provide the spraying end of a fuel injection valve stem with an integral fluid fuel strainer fitting and seating within a nozzle tip removably or detachably secured to the correlated valve body thereof; to provide a cross-head guide for said valve stem exteriorly of the stuffing box thereof; and to provide a separable overbalance body or chamber removably or detachably secured to the fuel injection valve having unobstructed communication with the fluid fuel under high pressure and fitted preferably with a fluid pressure actuated spring-pressed stem of slightly larger diameter than said valve stem and bearing thereupon, all as herein shown and for the purposes and uses herein described. In this connection I desire to state that while I have shown the overbalance stem 39 in alignment with the valve stem 20, it is not essential and necessary for the functioning of such over-balance stem 39 to be in perfect axial alignment therewith, as such stem 39 will function when slightly out of alignment, or when angularly disposed relative to said valve stem 20.

While I have herein shown and described my invention with sufficient detail to enable those skilled in the art to understand the mode of construction and the principles involved, it is to be understood that there is no intentional limitation herein to the specific form and precise details of construction of the invention shown and described, except

as expressly defined by the appended claims, and that various modifications of said construction may be resorted to without departing from the invention or the benefits derivable therefrom. I also desire to have it understood that certain features of the invention herein shown and described may be employed in other combinations than those herein shown.

10 Having thus fully described my invention what I claim as new and desire to secure by Letters Patents is:—

1. In a fuel injection valve, in combination, a valve body, a valve stem seated therein having a longitudinally and peripherally grooved fluid fuel strainer formed thereon with the longitudinal and peripheral grooves thereof disposed in intersecting relation, and an actuator for said valve stem.

20 2. In a fuel injection valve, in combination, a valve body, a valve stem seated therein having an integral longitudinally and peripherally grooved fluid fuel strainer formed upon the discharge end thereof with its longitudinal and peripheral grooves disposed in intersecting relation, and means to actuate said valve stem.

3. In a fuel injection valve, in combination, a valve body a nozzle tip secured thereon, a valve stem disposed within said valve body having a longitudinally and peripherally grooved fluid fuel strainer snugly fitting within said nozzle tip with its longitudinal and peripheral grooves disposed in intersecting relation, and an actuator for said valve stem.

4. In a fuel injection valve, in combination, a valve body, a nozzle tip secured thereon having a spraying orifice and a valve seat formed therein, a valve stem disposed within said valve body having a longitudinally and peripherally grooved fluid fuel strainer snugly fitting within said nozzle tip with the terminal thereof seating upon said valve seat and with its longitudinal and peripheral grooves disposed in intersecting relation, and means to actuate said valve.

5. In a fuel injection valve, in combination, a valve body, a nozzle tip removably secured thereon having a plurality of radially disposed spraying orifices formed therein, a valve stem disposed within said valve body having an integral fluid fuel strainer snugly fitting and seating within said nozzle tip, and means to actuate said valve stem.

6. In a fuel injection valve, in combination, a valve body; a nozzle tip removably secured thereon having an internal bore of two diameters, the smaller of said bores having a discharge orifice; a valve seat formed within said nozzle tip at the juncture of said bores; a valve stem disposed within said valve body having a fluid fuel strainer snugly fitting within said nozzle tip with the terminal thereof seating upon said valve

seat; and means to actuate said valve stem.

7. In a fuel injection valve, in combination, a valve body; a nozzle tip removably secured thereon having an internal bore of two diameters, the smaller of said bores having a plurality of radially disposed orifices; a valve seat formed within said nozzle tip at the juncture of said bores; a valve stem disposed within said valve body having an integral fluid fuel strainer snugly fitting within the larger of said bores and provided upon the extremity thereof with a portion of reduced diameter having the terminal thereof seated upon said valve seat; and means to periodically actuate said valve stem.

8. In a fuel injection valve, in combination, a valve body having an interiorly enlarged and exteriorly threaded discharge terminal; a nozzle tip fitting and seating at the inner end thereof within said discharge terminal and having an interior bore of two diameters, the smaller perforated bore of which forms and constitutes the fuel outlet chamber of said nozzle tip; a valve seat formed within said nozzle tip at the juncture of said bores; a union nut threadably engaged upon the exteriorly threaded discharge terminal of said valve body to maintain the inner end of said nozzle tip in fitting and seating relation therein; a valve stem disposed within said valve body having an integral fluid fuel strainer snugly fitting within the larger of said bores and provided upon the extremity thereof with a cylindrical portion of reduced diameter forming thereat conjointly with the lower end of said larger bore, a fuel collecting chamber for said nozzle tip and having the terminal thereof seating upon said valve seat; and means to actuate said valve stem.

9. In a fuel injection valve, in combination, a valve body, a nozzle removably secured thereon, a valve stem disposed within said body having an integral fluid fuel strainer snugly fitting and seating within said nozzle, a stuffing box for said valve stem disposed within said body, a guide for said valve stem disposed exteriorly of said stuffing box, and an actuator for said valve stem.

10. In a fuel injection valve, in combination, a valve body, a valve stem seated therein, a stuffing box for said valve stem disposed within said body, a crosshead adjustably secured upon the end of said valve stem exteriorly of said stuffing box, a lock nut threadably mounted upon said stem for abutment with said crosshead, a guide for said crosshead secured to said valve body, and an actuator for said valve stem.

11. In a fuel injection valve, in combination, a valve body, a valve stem seated therein, a stuffing box for said valve stem disposed within the upper end of said body, a yoke fitting upon and fixedly secured to the upper end of said valve body, a cylindrical

crosshead adjustably secured upon the upper end of said valve stem exteriorly of said stuffing box and guided for reciprocation within the upper end of said yoke, a lock nut threadably mounted upon said stem for abutment with said crosshead, and an actuator for said valve stem.

12. In a fuel injection valve, in combination, a valve body, a valve stem seated therein, a separable over-balance body removably secured upon said valve body and communicating with the fluid fuel supply of said valve, a fluid fuel pressure actuated over-balance stem disposed within said over-balance body of a slightly larger diameter than said valve stem with the adjacent ends of said stems normally in contact to over-balance and provide a surplus pressure upon said valve stem to normally seal the same upon the seat thereof adjustable compression spring means for said overbalance stem, and mechanism to lift said valve stem.

13. In a fuel injection valve, in combination, a valve body, a valve stem seated therein, a separable over-balance body removably secured upon said valve body and communicating with the fluid fuel supply of said valve under pressure, a fluid pressure actuated over-balance stem slidably disposed within said over-balance body of a slightly larger diameter than said valve stem having the lower end thereof contacting with the upper end of said valve stem to over-balance and provide a surplus pressure thereon to normally seal the same upon the seat thereof, a compression spring interposed between the upper ends of the over-balance body and correlated stem thereof to overcome friction of working parts of said valve at extremely low pressures means to regulate said compression spring, and mechanism to lift said valve stem.

14. In an airless fluid fuel injection valve, in combination, a valve body, a valve stem seated therein having a fluid fuel strainer integrally formed thereon, and an actuator for said valve stem.

15. In a hydraulic injection valve for injecting fluid fuel under pressure into the combustion chambers of internal combustion engines, in combination, a valve body, a reciprocable valve stem seated therein having a fluid fuel strainer integrally formed thereon and snugly fitting within said valve body for intercepting foreign particles carried in suspension by the fluid fuel, and means to reciprocate said valve stem.

16. In a fuel injection valve, in combination, a valve body having a fuel collecting chamber formed within the discharge end thereof, a reciprocable valve stem seated therein having its inner terminal portion threaded and a series of longitudinal grooves cut in said threaded portion, alternate grooves of said series communicating at their

upper ends with the interior of said valve body and the other grooves of said series communicating at their lower ends with said fuel collecting chamber, said threaded and grooved portion being adapted to snugly fit within said valve body whereby the fluid fuel passing therethrough is strained and foreign particles suspended therein are intercepted, and means to reciprocate said valve stem.

17. A valve stem for a fluid fuel injection valve having a strainer for fluid fuel integrally formed thereon.

18. A valve stem for a fluid fuel injection valve having a strainer for fluid fuel integrally formed upon the inner terminal portion thereof.

In testimony whereof I affix my signature.
ADRIAN C. ESTEP.