Sept. 17, 1940. C. R. ALDEN 2,214,757

NOZZLE

Original Filed Dec. 10, 1937 2 Sheets-Sheet 1

Fig. 1

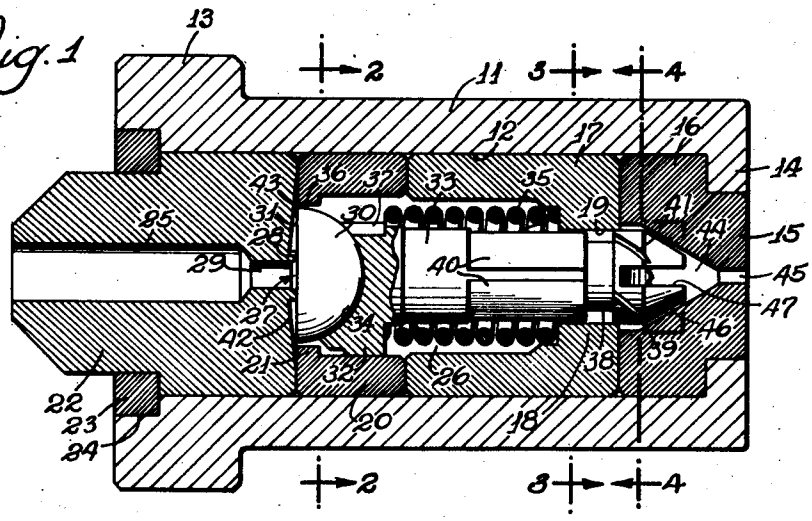


Fig. 2

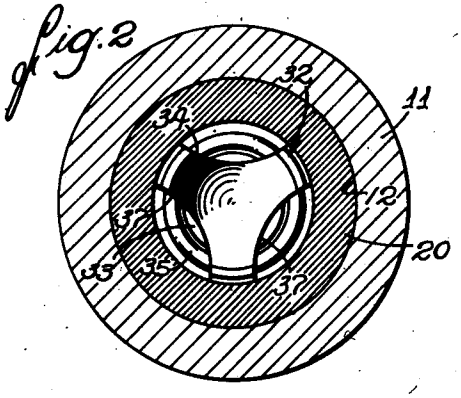


Fig. 3

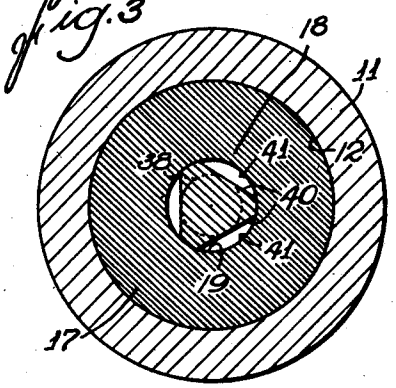
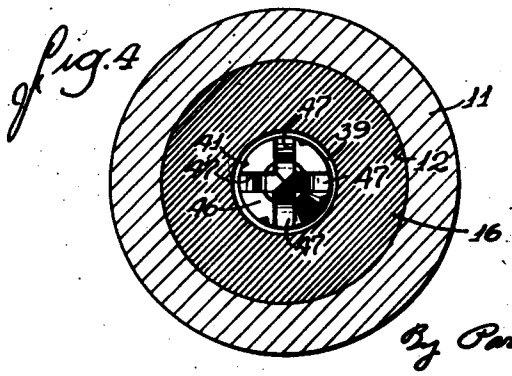


Fig. 4



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Fig. 5

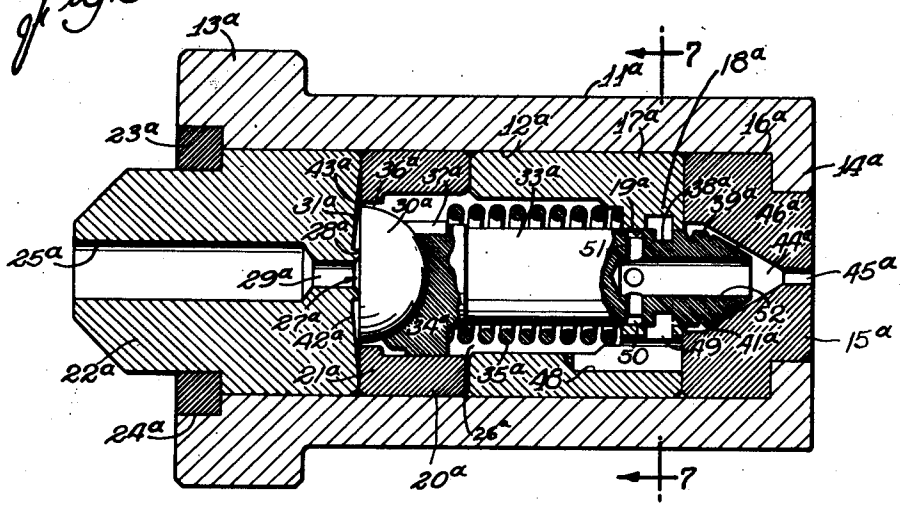


Fig. 6

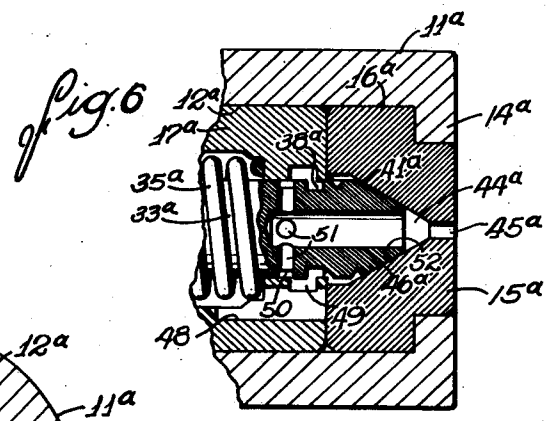
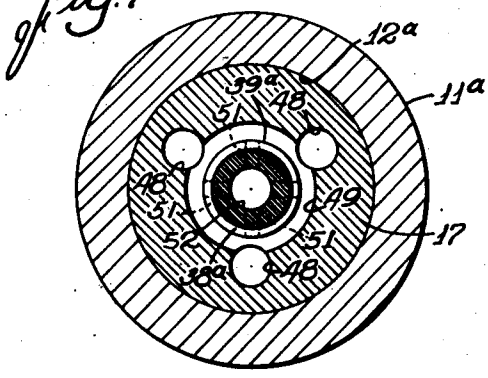


Fig. 7



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UNITED STATES PATENT OFFICE

2,214,757

NOZZLE

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Application December 10, 1937, Serial No. 179,069
Renewed December 13, 1939

13 Claims. (Cl. 299—107.6)

The present invention relates to improvements in nozzles adapted particularly for delivering timed metered injections of liquid fuel in connection with the operation of internal combustion engines.

One of the important objects of the present invention is to provide a novel fuel injection nozzle in which proper atomization of the fuel and maximum penetration consistent therewith of the issuing jet or spray into the combustion space are obtained at all rates of injection.

Another object is to provide a new and improved plain orifice nozzle in which the manner of approach of the fuel to the orifice is varied to change the discharge characteristics in accordance with changes in the rate of injection.

A further object is to provide a novel plain orifice nozzle in which the coefficient of discharge of the orifice is controlled by the flow of the fuel.

A more specific object is to provide a new and improved fuel injection nozzle with a plain discharge orifice in which the fuel is caused to issue from the orifice as a jet or spray varying progressively from a centrifugal form to a non-centrifugal form in the course of the valve opening movement, whereby the coefficient of discharge and hence the flow capacity of the orifice are progressively increased to obtain the required dispersion and penetration characteristics not only at maximum rates of delivery but also at low and medium rates of delivery.

A further object is to provide novel means for effecting a positive conversion of the flow characteristics in the course of the valve opening movement, and particularly for breaking up or eliminating the rotational swirl of the fuel upon movement of the valve into fully open position.

Still another object is to provide a novel flow-controlled fuel injection nozzle with a plain discharge orifice in which initial, intermediate and final flow restrictions of progressively increased flow areas are successively effective to set up opening pressure assistances in the course of the valve opening movement, and in which the intermediate restriction is also effective within its range to vary the coefficient of discharge of the orifice as required to maintain a proper injection pressure at low and medium rates of delivery.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings,

Figure 1 is a longitudinal sectional view of a nozzle tip embodying the features of my invention.

Figs. 2, 3 and 4 are transverse sectional views taken respectively along lines 2—2 to 4—4 of Fig. 1.

Fig. 5 is a longitudinal sectional view of a modified form of nozzle tip with the valve in fully closed position.

Fig. 6 is a fragmentary view of the tip illustrated in Fig. 5, but with the valve in fully open position.

Fig. 7 is a transverse sectional view taken along line 7—7 of Fig. 5.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

The present invention is an improvement of the nozzle tips disclosed in my copending applications Serial No. 152,074, filed July 6, 1937, and Serial No. 158,639, filed August 12, 1937. Any subject matter common to this application and either of said copending applications is claimed in the earliest filed application.

Referring more particularly to the drawings, the fuel injection nozzle illustrated in Figs. 1 to 4 comprises a suitable body or housing 11. Preferably, the body 11 is in the form of a tubular shell defining an axial bore 12, and having an external peripheral flange 13 at the base end and an internal peripheral flange 14 at the discharge end.

The discharge end of the shell 11 is closed by an orifice head 15 which has suitable orifice means with the desired fuel discharge characteristics, and which preferably is removable to permit substitution for different spray patterns and characteristics. The orifice head 15 may be provided in any desired form, and in the present instance is shown as a circular plate or block extending snugly through the flange 14, and having a peripheral mounting flange 16 seating snugly within the bore 12 against the inner face of the flange 14.

A generally tubular spacer 17, having an inner peripheral flange 18 at the outer end defining an axial guide bore 19, is removably fitted into the shell 11 and serves to hold the plate 15 in position. Removably positioned against the inner end of the spacer 17 is a tubular valve body 20 having an inner peripheral end flange 21.

A stationary member 22 in the form of a cylindrical valve plug is removably fitted into the base end of the shell 11 against the body 20, and serves to hold the various parts within the shell 11 in assembled position. Suitable plastic means 23 may be pressed into an annular groove 24 having opposed complementary sections in the base end of the shell 11 and the member 22, and serves to seal and maintain the assembly. The member

22 is formed with an axial fuel inlet passage 25 adapted for a fluid-tight connection with a fuel pump or other suitable means (not shown) for supplying the fuel to be injected.

It will be understood that the assembly just described constitutes the rigid structure of the nozzle tip, and as such is adapted to be connected to the source of fuel supply, and to be clamped or secured to the engine at the desired point of injection a nozzle holder or other suitable means, not specifically disclosed herein since per se it forms no part of the present invention, may be utilized for this purpose as is well understood in the art. The rigid structure of the nozzle tip is susceptible of various modifications and alternative forms without departing from the broad aspects of the present invention, and in general provides an internal chamber 26, defined by the spacer 17 and the body 20, and adapted for communication with the inlet passage 25 and to discharge through the orifice body 15.

The supply of fuel under pressure, from the inlet passage 25 to the chamber 26 for injection through the orifice head 15 into the combustion space, is under the control of a nozzle valve 27. Within the broad aspects of the invention, the valve 27 may be of any suitable form or character. In the present instance, the valve 27 is spring seated against the pressure of the fuel, and opens outwardly in the direction of the fuel flow. More particularly, the valve 27 comprises a flat annular valve seat 28 formed in the inner end of the valve plug 22, and encircling a valve passage 29 opening from the passage 25. A movable valve member 30, herein shown in the form of a partial or half ball, has a flat valve face 31 adapted for engagement with the seat 28. When the valve member 30 is seated, the seat 28 defines a central pressure area A_V on the face 31 exposed to the fuel pressure in the passage 29.

Any suitable means may be provided for supporting the valve member 30, and in the present instance this means comprises a retainer 32 in the form of a circular head slidably guided in the valve body 20 and rigid with the inner end of an axial stem 33 guided in the bore 19. To permit self-alignment with the valve seat 28, the spherical portion of the valve member 30 is seated for universal adjustment in a partial spherical socket 34 formed in the free end face of the retainer head 32. A coiled compression spring 35 closely encircles the stem 33, and abuts at opposite ends against the spacer flange 18 and the head 32 to urge the valve member 30 toward or against the valve seat 28 with a predetermined spring pressure.

The valve member 30 is reciprocably disposed within the confines of the flange 21, and coacts therewith to define an annular flow passage 36. Formed in the periphery of the head 32 are a plurality of longitudinal flutes 37 (see Fig. 2) which provide unrestricted flow passages from the passage 36 to the chamber 26 about the stem 33. The outer end portion of the stem 33 is formed with a peripheral groove 38 defining a head 39 slidable with a close fit in the outer end of the bore 19, and is also formed on the periphery with a plurality of longitudinal flats 40 (see Fig. 3) defining flow passages opening from the chamber 26 to the groove 38. A plurality of grooves 41 in the periphery of the head 39 serve to connect the groove 38 to the orifice means in the orifice head 15. It will be understood that the flow path of the fuel from the valve 27 to the orifice head 15 leads through the passage 36, the flutes 37, the chamber 26, the passages along the flats 40, the groove 38 and the grooves 41.

Upon the application of fuel pressure from any suitable source of timed delivery of metered fuel quantities, static pressure is first applied to the area of the ball element 30 exposed to the valve passage 29 at the valve seat 28, i. e., the valve opening pressure area A_V. When the hydraulic pressure times the area A_V overbalances the pressure of the spring 35, the valve 27 will open to permit the flow of fluid to the orifice head 15 at which point hydraulic pressure is again built up by reason of the orifice restriction.

The opening of the valve 27 is made at least in part responsive to the rate of fuel flow so that the applied hydraulic pressure may be limited and controlled as desired throughout the range of valve movement. More particularly, a plurality of flow restrictions or resistances of different flow areas are interposed in the path of fuel flow, and are successively effective over different portions of the injection range in the opening and closing movements of the valve 27. Each of these restrictions when in control tends to build up a differential pressure responsive to the rate of flow and separate from the injection pressure and acting on a lifting area A_d larger than the valve opening area A_V. By reason of this difference in area, a relatively small pressure differential is required to move and hold the valve 27 open, and hence the remaining pressure of the total applied pressure is relatively high and is utilized solely for injection purposes to obtain the desired atomization and penetration. The subdivision of the pressure to perform the separate functions makes possible a heavy lifting action without objectionably disturbing the injection characteristics of the nozzle.

Each flow restriction in coaction with the associated pressure area sets up a valve opening pressure assistance. In the present instance three assistances A, B and C have been provided. It will be understood that the flow restrictions may be provided in any suitable manner, and may be varied widely in form and character depending on the operating characteristics desired.

The assistance A is in control when the valve member 30 is in close proximity to the seat 28, and causes the initial opening movement and the final closing movement of the valve 27 to occur with extreme rapidity. It is transient or disappearing in character in the opening movement of the valve 27. To obtain the assistance A, the annular valve seat 28 is peripherally relieved by an encircling groove or recess 42 formed in the plug 22, thereby providing a small seat area. As a result, the seat pressure is sufficiently high to collapse or extrude the oil film between the valve faces when the valve 27 is closed. The bottom of the groove 42 is inclined outwardly toward the face 31 of the valve member 30, and coacts with the peripheral edge of the latter to define a small annular flow restriction 43. By inclining the bottom of the groove 42, the seat 28 is conveniently provided with a substantial relief, and the effective minimum area or clearance of the small flow restriction 43 may be readily and accurately determined by the use of mathematics, the depth of the seat relief, the angle and the radial dimensions of the half ball 30 and seat 28 being known. The bottom of the groove 42 being closely spaced from the peripheral edge of the half ball 30 also serves approximately to square up the latter with the seat 28. Hence, the half ball 30 cannot engage the seat 28 at an angle suffi-

ciently large to cause damage or result in valve leakage.

When the hydraulic pressure from the source of supply acting on the closed valve area A_V is sufficient to overcome the force of the spring 35, the valve 27 will open. After the initial opening movement, the annular restriction 43 builds up a pressure differential which is applied to the flat face area 31 of the valve member 30, and which assists the initial force to accelerate rapidly the first portion of the valve movement, so that the valve member 30 is caused to leave the seat 28 with a popping action. Since the area 31 is much larger than the valve area A_V, the differential pressure required to move the valve member 30 is considerably lower than the valve opening pressure, and makes available immediately a high pressure for injection with proper atomization. If the valve opening movement continues, as for the delivery of large quantities of fuel, the initial assistance A, quickly disappears, thereby reducing the pressure drop at the seat and releasing more pressure for injection. The assistance A also serves to accelerate rapidly the final closing movement of the valve 27. As the valve member 30 moves into close proximity to the seat 28, the restriction 42 again becomes effective, and sets up a differential pressure acting on the ball area 31 in opposition to the closing movement. However, when the rate of flow drops to a point where the assistance A is no longer effective to balance the closing force, the spring 35 will move the valve member 30 rapidly toward the seat 28 to close the valve 27 with a popping action.

The assistance B becomes effective after disappearance of the assistance A, and serves to control the transition from the slowest rates of delivery to medium rates of delivery. To obtain this assistance, the grooves 41 are formed to define a flow restriction tending to set up a differential pressure acting outwardly on an effective area equal to the transverse area of the stem 33. As the head 39 moves outwardly of the bore 19 in the opening movement of the valve 27, the effective length of the grooves 41 is shortened, thereby reducing the flow restriction. Hence, the assistance B also is transient or disappearing in character so as to be effective only over the intermediate range of injection.

The final assistance C becomes effective after disappearance of the assistance B, and hence controls the transition from medium rates of delivery to maximum rates of delivery. To obtain this resistance, the clearance between the flange 21 and the peripheral edge of the valve member 30 is small so that the passage 36 defines a flow restriction tending to set up a differential pressure acting outwardly on the face 31. It will be understood that the valve may open to any point in the range of movement depending on the rate and quantity of injection. The assistances A, B and C would be relatively so proportioned as to cooperate to obtain the desired result. For further details as to the function and operation of the assistances A, B and C, reference may be had to the aforesaid copending application, Serial No. 152,074.

The orifice head 15 may be provided in various forms depending on the spray characteristics desired. In Fig. 1, the head 15 is formed in the inner face with an injection pressure chamber 44 which registers with the bore 19 to receive the head 39 in the opening movement of the valve 27, and which opens axially to a single plain hole discharge orifice 45.

One of the important features of the present invention is to vary the discharge characteristics of the orifice 45 in accordance with the rate of fuel flow so as to obtain proper atomization and penetration at all rates of delivery, and particularly to permit the delivery of very small quantities of fuel without the presence of objectionable solids through a fixed orifice otherwise of sufficient size for maximum injection. This is accomplished by changing the manner of approach of the fuel to the orifice 45 whereby to vary the coefficient of discharge as required. The degree of atomization is a function of the pressure applied at the orifice, and the pressure varies as the square of the velocity times the coefficient of discharge. If this coefficient is constant, the pressure at low rates of delivery may be too low to break up the fuel. By varying the coefficient, an effect comparable to a variation in the size of the orifice is obtained.

To control the coefficient of discharge of the orifice 45, a variable centrifugal action is imparted to the entering fuel. In Fig. 1, the centrifugal action is obtained by means of the grooves 41 which preferably are V-shaped and of suitable flow area and proportions in cross-section, and which are formed with a suitable helical lead to impart a swirl to the fuel passing therethrough. The swirl of the fuel reduces the coefficient of discharge, and hence builds up an injection pressure in the chamber 44 sufficient to effect proper atomization. Since the head 39 moves outwardly into the chamber 44, the effective length of the grooves 41 is progressively decreased in the course of the valve opening movement. Hence, the coefficient of discharge is the lowest at minimum rates of delivery and increases progressively through the range of the assistance B. Upon movement of the peripheral groove 38 into direct communication with the chamber 44, the grooves 41 cease to be effective to impart a centrifugal or rotational swirl to the incoming fuel, and the fuel jet issuing from the orifice 45 tends to become non-centrifugal.

The groove belt defined by the head 39 has a close and uniform sliding fit with the bore 19 so that the grooves 41 will have maximum effectiveness in defining the flow passages therethrough and in varying their restrictive action with changes in the valve lift. The spiral grooves 41 should have a flow area sufficiently restricted to make the assistance B effective, but not restricted to an extent resulting in interference with the proper functioning of the assistance A.

The helix angle of the grooves 41, i. e., the lead along the stem axis, may be varied within limits depending on the atomization and penetration characteristics desired, without departing from the invention. Ordinarily, the helix angle should be the maximum consistent with desired atomization at low rates of injection. Decreasing the helix angle results in a greater centrifugal action and a corresponding decrease in the coefficient of discharge. A greater cone spray angle, with increased atomization, is thereby obtained, and the jet penetration is decreased. Increasing the helix angle results in a smaller spray cone angle and increased jet penetration.

After the grooves 41 leave the bore 19, the assistance C is adapted to accomplish the last step in moving the valve 29 into fully open position. During this step, the grooves 41 are no longer effective to impart a centrifugal action to the fuel in the entry to the orifice 45, but the rotational swirl may persist for a time because of the

residual centrifugal action. An important feature of the present invention is to break up or eliminate quickly and effectively any residual swirl when the valve moves into fully open position so as to obtain a spray with maximum penetration characteristics after the swirl initially imparted has served its purpose. This is accomplished by a positive conversion of the flow characteristics from centrifugal to non-centrifugal.

To effect the conversion, the head 39 is formed with an end extension 46, and this extension and the peripheral surface of the chamber 44 in the orifice plate 15 are conical or tapered in form for engagement to prevent the discharge of the swirling fuel when the valve 27 reaches full open position. The groove belt of the head 39 is cylindrical in form, and spaced peripherally from the surface of the chamber 44. The head 39 is also formed with passage means 47 effective to direct the fuel non-centrifugally to the orifice 45 when the extension 46 engages the orifice plate 15 to cut off the peripheral flow. In the present instance, the passage means 47 consists of a plurality, for example four, uniformly spaced radial slots which open to the groove belt of the head 39, and which intersect each other longitudinally in alignment with the orifice 45. These slots do not interfere with the rotary motion of the fuel in the entry to the orifice 45 as long as the fuel is free to swirl about the head extension 46. However, when the extension 46 comes into engagement with the orifice plate 15, rotary motion of the fuel is no longer possible, and the fuel must flow radially inwardly from the periphery of the head 39 through the slots 47, and thence axially outward through the orifice 45. The slots 47 therefore become effective immediately upon movement of the valve 27 into full open position to remove or break up any residual swirl in the fuel.

The modified form illustrated in Figs. 5 to 7 is closely similar to the form just described, and hence corresponding parts will be identified by the same reference numerals plus the letter *a*, and only the differences in construction will be specifically described. In this form, all possible effect of any residual swirl is completely eliminated immediately upon movement of the valve 27ª into fully open position.

The valve stem 33ª in this instance is cylindrical instead of fluted. A plurality of peripherally spaced longitudinal bores 48, for example three, are formed in the outer end of the spacer 17ª and open from the chamber 26ª to define flow passages. Formed in the flange 18ª in which the stem 33ª is guided is an internal annular groove 49 which intersects the bores 48 to establish communication therewith, and which is always open to the groove 38ª. The groove belt of the head 39ª, with the restricted helical or inclined grooves 41ª is movable into and out of the bore 19ª, and the conical or tapered end extension 46ª is movable into engagement with the orifice plate 15ª to cut off completely the path of flow from the grooves 41ª to the orifice 45ª when the valve 27ª is fully open.

Formed in the stem 33ª in axially spaced relation to the groove 38ª is an annular by-pass groove 50. This groove is movable into and out of communication with the supply groove 49, and is connected through radial ports 51 to an axial bore 52 in and opening to the end of the stem 33ª.

When the valve 27ª is in or near closed position, fuel from the chamber 26ª is free to pass through the bores 48, the grooves 49 and 38ª, the grooves 41ª and the chamber 44ª to the orifice 45ª. At this time, the grooves 49 and 50 are out of communication so that no flow occurs through the bore 52 and all of the fuel is discharged centrifugally. After a predetermined valve movement, for example midway of the range, the groove 50 moves into communication with the groove 49. Now, the fuel is free to flow not only through the restricted grooves 41ª which impart the centrifugal action, but also non-centrifugally from the groove 49 through the groove 50, the ports 51 and the bore 52 to the orifice 45ª. As the valve opening movement continues, the flow through the centrifugal grooves 41ª is decreased progressively while that through the bore 52 is increased. When the stem 33ª engages the orifice plate 15ª, the centrifugal flow is completely eliminated, and all the fuel is caused to flow without centrifugal action through the bore 52.

I am cognizant of the fact that the operation of the nozzle may be influenced to some extent by the pressure in the combustion chamber of the engine, but for the purpose of simplicity in describing the invention have disregarded this factor particularly since it can be compensated for by proper selective design of the nozzle parts.

I claim as my invention:

1. In a fuel injection nozzle, in combination, a body having a fuel inlet and a fixed discharge orifice of constant flow area, valve means for controlling the supply of fuel under pressure for discharge through said orifice, means operable in the initial opening movement of said valve means for imparting a centrifugal action to the fuel entering said orifice, and means for positively eliminating said action upon further opening movement of said valve means into a predetermined position.

2. In a fuel injection nozzle, in combination, a body having a fuel inlet and a fixed discharge orifice of constant flow area, valve means for controlling the supply of fuel under pressure for discharge through said orifice, and means operable in the opening movement of said valve means to cause the fuel to issue through said orifice initially in the form of a centrifugal envelope of progressively decreasing cone angle and finally in the form of a non-centrifugal spray, said last mentioned means being operable to effect a positive conversion from said envelope to said non-centrifugal spray.

3. In a fuel injection nozzle, in combination, a body having a circular chamber with an axial inlet bore opening thereto, a spring-seated valve for controlling the supply of fuel to said bore and opening in the direction of fuel flow, a head movable with said valve and slidable with a close fit progressively into and out of the outlet end of said bore, a plurality of helical grooves formed in the periphery of said head and opening to the opposite ends thereof, said head when in said bore coacting with said bore to constitute said grooves restricted flow passages in the path of fuel flow from said bore to said chamber variable in effective length in accordance with the extent of valve opening, said passages being adapted to impart a centrifugal action to the fuel in said chamber and to build up a differential pressure acting as a valve opening assistance, a fixed discharge orifice opening axially from said chamber, and means operable after movement of said head out of said bore to effect elimination of residual

centrifugal action of the fuel and to discharge the fuel non-centrifugally to said orifice.

4. In a fuel injection nozzle, in combination, a hollow body having an inner chamber with a fuel inlet at one end and a fixed discharge orifice at the other end, a spring seated valve for controlling the supply of fuel through said inlet to said chamber and opening in the direction of fuel flow, means for defining a plurality of peripherally inclined restricted flow passages decreasing progressively in effective length in accordance with the opening movement of said valve and causing the fuel to enter said orifice centrifugally, and means for eliminating the residual centrifugal action of said fuel when said passages become ineffective.

5. In a fuel injection nozzle, in combination, means defining a chamber having a fuel inlet and a fuel outlet, spring-seated valve means for controlling the supply of fuel to said inlet, and means operable with said valve means and cooperating with said inlet in the valve opening movement to define first a flow passage through said chamber for causing the fuel to issue centrifugally from said orifice and upon movement of said valve means into fully open position to close said passage and establish a parallel passage for causing the fuel to issue non-centrifugally from said orifice.

6. In a fuel injection nozzle, in combination, a hollow body having a chamber with an inlet bore at one end and a discharge orifice at the other end, a spring-seated valve for controlling the supply of fuel through said inlet to said chamber and opening in the direction of fuel flow, a valve stem movable with said valve and having a head spaced from said valve with an inclined groove coacting with said inlet to impart a rotational swirl to the entering fuel, said head being movable into engagement with the surface of said chamber to interrupt the flow of fluid from said chamber through said groove to said orifice, and a passage formed in said head for discharging fluid from said inlet non-centrifugally to said orifice.

7. In a fuel injection nozzle, in combination, a hollow body having a chamber with an inlet at one end and a discharge orifice at the other end, a spring-seated valve for controlling the supply of fuel through said inlet to said chamber and opening in the direction of fuel flow, and means movable with said valve and having a head with an inclined groove coacting with said inlet during the initial portion of the opening movement of said valve to impart a rotational swirl to the entering fuel, said head being movable into engagement with the surface of said chamber during the final portion of the opening movement of said valve to render said groove ineffective and to interrupt the centrifugal flow of fluid from said chamber through said groove to said orifice.

8. In a fuel injection nozzle, in combination, a body having a chamber of conical form, an orifice opening from said chamber at the apex, a bore opening to said chamber in axial alignment with said orifice, and an annular internal groove in said bore, a stem slidable in said bore and having a first annular external groove open to said internal groove and a second annular external groove movable into communication with said internal groove, an axial bore in said stem and opening from said second groove to said orifice, and an inclined groove formed in the periphery of said stem from said first external groove to said chamber and movable progressively out of said first mentioned bore, said stem having a tapered end engageable with the surface of said chamber to close the passage from said inclined groove to said orifice upon movement of said inclined groove out of said first mentioned bore and of said second groove into communication with said internal groove.

9. In a fuel injection nozzle, in combination, means defining a chamber having a fuel inlet bore and a fuel outlet, spring-seated valve means for controlling the supply of fuel to said bore, a stem movable with said valve means and having a cylindrical groove belt movable from said chamber into and out of said bore, an inclined groove in the periphery of said belt and coacting with said bore when said head is in said bore to define a restricted flow passage from said bore to said chamber and to impart a centrifugal force to the fuel passing therethrough, an extension on said stem movable into cooperative relation with said body upon movement of said belt out of said bore to interrupt the flow of swirling fuel to said outlet, and a radial slot in said stem opening from said belt through said extension to establish a flow passage for directing fuel from said chamber non-centrifugally to said outlet when the flow of swirling fluid to said outlet is interrupted.

10. In a fuel injection nozzle, in combination, a body having a fuel inlet and a discharge orifice, valve means for controlling the supply of fuel under pressure for discharge through said orifice, and means operable in the opening movement of said valve means to cause the fuel to issue through said orifice initially in the form of a centrifugal envelope of progressively decreasing cone angle and finally in the form of a non-centrifugal spray, said last mentioned means being operable to effect a positive conversion from said envelope to said noncentrifugal spray.

11. In a fuel injection nozzle, in combination, a hollow body having a fuel inlet and a discharge orifice, a spring seated valve for controlling the supply of fuel from said inlet to said orifice and opening in the direction of fuel flow, means for defining a peripherally inclined restricted flow passage in the path of fuel flow and decreasing progressively in effective length in accordance with the movement of said valve in one direction and causing the fuel to enter said orifice centrifugally, and means for eliminating the residual centrifugal action of said fuel when said passage becomes ineffective.

12. In a fuel injection nozzle, in combination, a body having a fuel inlet and a fuel outlet, and valve means for controlling the supply of said fuel from said inlet to said outlet, said valve means cooperating with said body to define first a flow passage to said outlet for causing the fuel to issue centrifugally and upon movement of said valve means into fully open position to close said passage and to establish a parallel passage to said outlet for causing the fuel to issue non-centrifugally.

13. In a fuel injection nozzle, in combination, a hollow body having a fuel inlet and a fuel outlet, and valve means for controlling the supply of said fuel from said inlet to said outlet, said valve means defining a first normally open spiral flow passage and a second normally closed parallel flow passage, and being operable in the opening movement into a predetermined open position to close said first passage and in the course of said movement to open said second passage.

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