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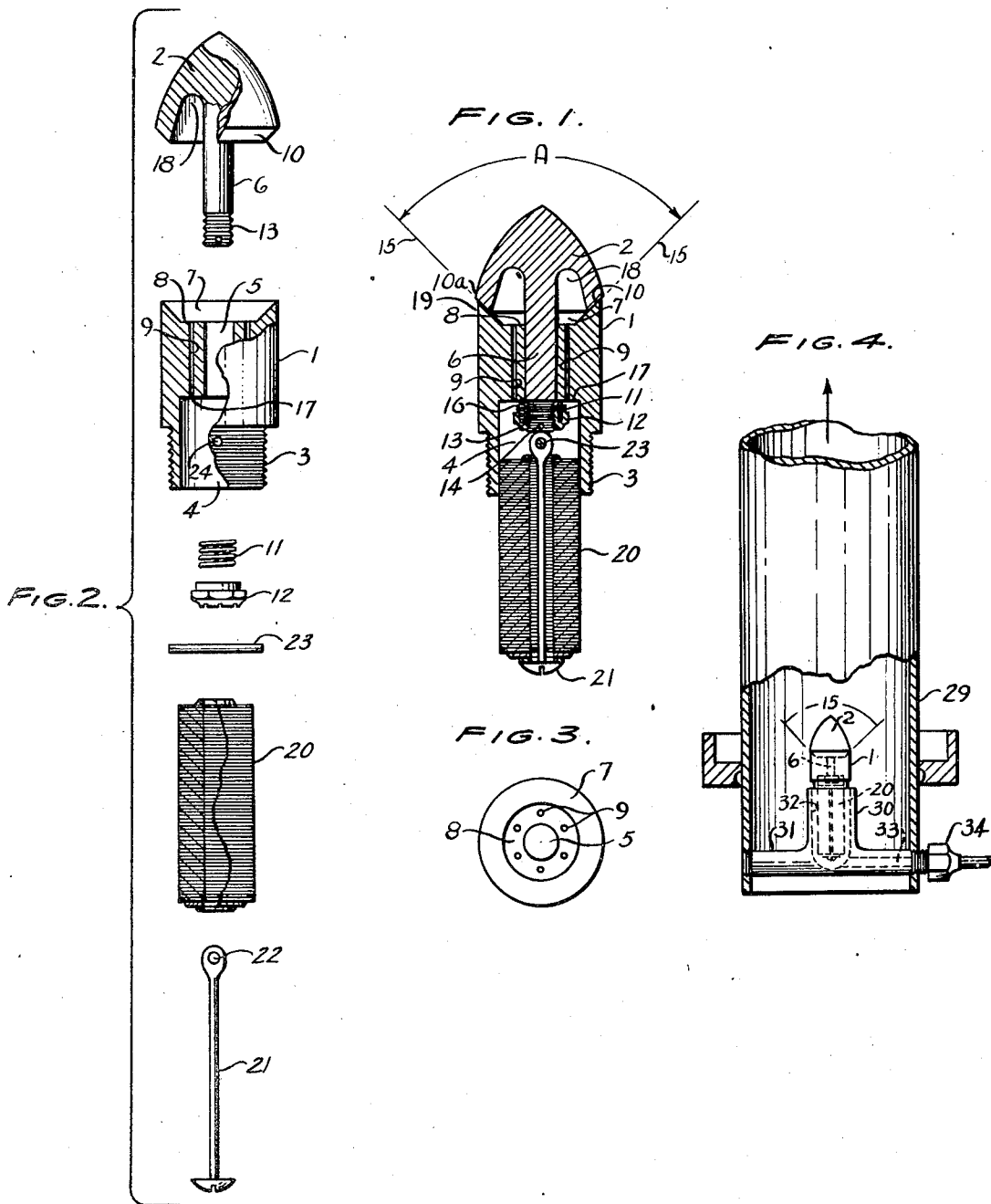
C. P. ROSS

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FUEL INJECTOR NOZZLE

Filed April 18, 1941

2 Sheets-Sheet 1



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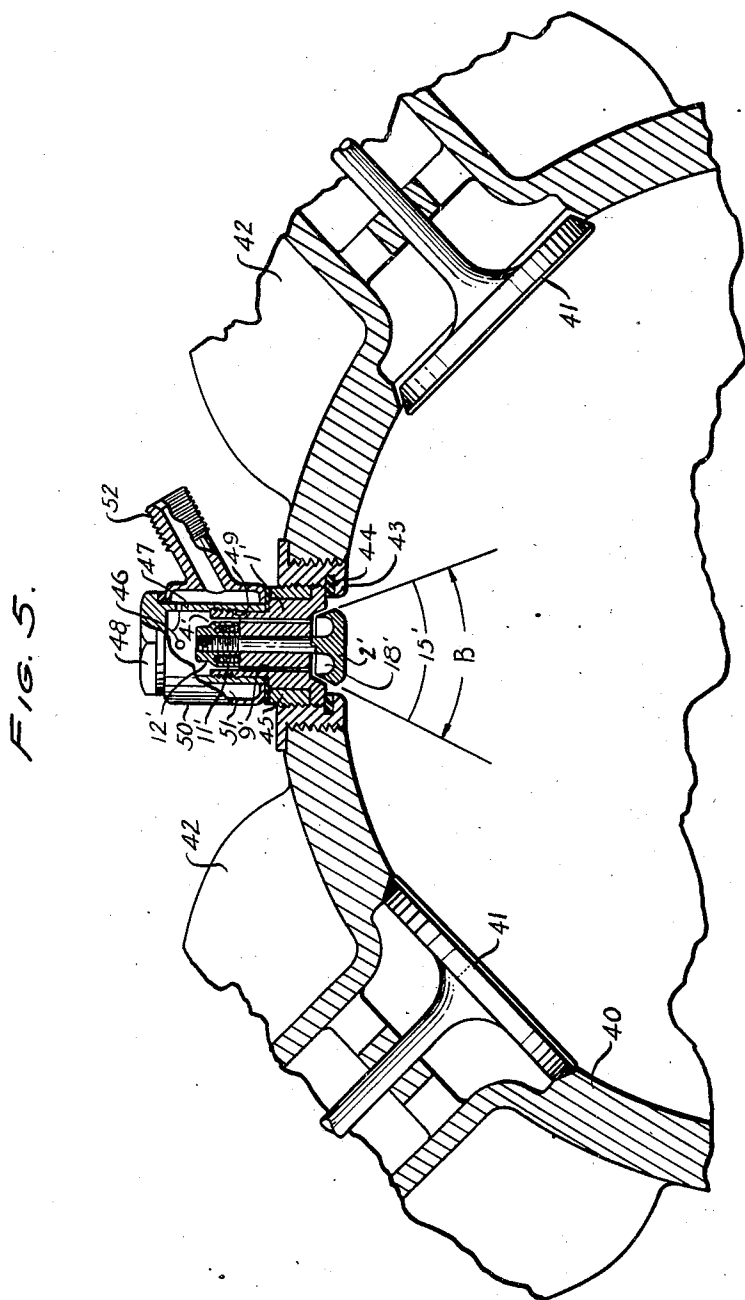
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2 Sheets-Sheet 2



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FUEL INJECTOR NOZZLE

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9 Claims. (Cl. 299—107.6)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to fuel injector nozzles for internal combustion engines.

The general object of this invention is to provide an improved fuel injector nozzle of the conical spray type which will overcome the objections to which known injector nozzles are subject. One of the primary requirements of a satisfactory fuel injector nozzle of this type is that the delivery be in the form of a fine mist uniform around the nozzle and free of stringiness. Present known nozzles have a marked tendency to produce a non-uniform, or stringy, fuel flow, which is undesirable. In certain instances a baffle ring has been added to improve the uniformity of the fuel delivery, but the added part or parts complicate the construction of the nozzle and are usually fragile and thus likely to become distorted in handling and shipping.

Another requirement, in the case of cylinder head nozzles, is that the operation of the nozzle must not be impaired by an accumulation of carbon deposits. In some of the known nozzles satisfactory operation may be obtained for a time, but in continued service they are rendered inoperative by the building up of carbon deposits, necessitating interruptions to service for cleaning and adjusting. Such a characteristic renders these nozzles too unreliable for use in aircraft engines where they might otherwise be superior to carburetors.

Injector nozzles should also be small in size, and should not require special cooling facilities, particularly for use in aircraft.

While some of these requirements and problems have been recognized in the prior art, yet the solution thereto has usually resulted in a complicated, and somewhat fragile apparatus which is expensive to manufacture and likely to get out of adjustment either before or after installation. The particular objects of the present invention are therefore to provide a fuel injector nozzle of rugged construction and having improved performance characteristics which are not likely to be affected deleteriously by reasonably rough handling before installation or by hard service after installation; to provide a nozzle of this type which has relatively few parts and is inexpensive to manufacture; and specifically, to provide an improved conical spray nozzle capable of producing a fine, misty spray which is uniform around the nozzle and free of string-

iness, which spray may be limited to a definite zone in the cylinder by forming the orifice to provide an appropriate apex angle for the cone of spray.

These and other objects and advantages will become apparent to one skilled in the art as the description proceeds in connection with the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view of a nozzle constructed according to the present invention, and having a streamlined cap particularly adapted for use in an intake manifold.

Fig. 2 is an exploded view of the nozzle shown in Fig. 1, with certain parts shown in section.

Fig. 3 is a top plan view of the body 1.

Fig. 4 is a view of a portion of an intake manifold with parts cut away to show the installation of the injector nozzle of Fig. 1 therein.

Fig. 5 is a sectional view of a cylinder head showing a modified form of nozzle especially adapted for cylinder head injection.

In the embodiment shown in Fig. 1, the injector nozzle of the present invention comprises primarily a body 1 and a cap 2 cooperating therewith. The cap 2 is adapted to be slightly lifted from the body 1 to form a spray nozzle, and to seat upon the body 1 to form a valve for regulating the timing of each spraying operation. The body 1 is provided at one end with a threaded portion 3 enclosing a central chamber 4, and has a communicating circular opening 5 extending to the other end and adapted to slidably receive a stem 6 on the cap 2. The said other end of the body 1 is provided with an accurately machined conical surface 7 extending from the cylindrical outer wall of the body inwardly to a transverse surface or wall 8. A plurality of fluid passages 9 extend from the wall 8 into communication with the central chamber 4.

The cap 2 is provided with a rim, or lip, 10a which is accurately machined in the form of a conical surface 10, and lapped to the surface 7. The seating of the surface 10 upon the surface 7 is normally maintained by the action of a spring 11 against a nut 12 adjustably carried on a threaded end 13 of the cap stem 6, and a pin or other locking means 14 is provided to prevent rotation of the nut 12 after the proper adjustment has been obtained. Thus the spring 11 normally seats the surface 10 tightly upon the surface 7 to effect a liquid seal within a certain range of pressures. When a sufficiently high pressure is developed within the chamber 4, the fluid reaction on the inner walls of the cap 2 and the lower end of the stem 6 will move the cap

2 upwardly, compressing the spring 11 and unseating the surfaces 7 and 10, so as to produce a conical spray 15. As long as the fluid-pressure reaction is sufficient to maintain the surfaces 7 and 10 separated, the spray 15 will continue, and as soon as the fluid-pressure reaction drops to a predetermined value, the spring 11 will snap the surface 10 into firm contact with the surface 7 to interrupt the spray, or injection. The spraying operation just described is initiated and timed solely by the pressure of the fuel introduced into the chamber 4 in response to the operation of a high-pressure-injection pump which is well understood in the art. The value of fluid pressure required to unseat the surface 10 and initiate the spray may be adjusted by varying the spring loading applied by the nut 12, and the maximum opening between the surfaces 7 and 10 is governed by the height of a shoulder 16 on the nut 12, the said shoulder being adapted to act as a stop against the surface 17 in the extreme open position of the cap 2. In the drawings, the clearance between the shoulder 16 and the surface 17 is exaggerated for clearness.

The cap 2 is provided with an annular recess or cavity 18 to intercept and break up the individual streams of fuel from the openings 9 when injection is taking place. In normal operation, just prior to the building up of sufficient fuel pressure to unseat the cap 2, the chamber 4, passages 9 and the cavity 18 will be completely filled with liquid fuel. When the time for injection arrives, fuel pressure in these parts will have increased to a value sufficient to start to move the cap 2 to separate the surfaces 7 and 10, and thereupon a small amount of fuel will be discharged in the form of a well defined conical spray, or mist. The volume of the cavity 18 is such as to always provide an ample supply of fuel immediately available for discharge upon the slightest opening between the surfaces 7 and 10. As soon as some of this supply escapes, it is replaced by high velocity streams through the passages 9 which impinge upon the curved walls of the recess 18 so as to thoroughly break up the individual streams and insure a uniform spray in the manifold, or cylinder. As the rate of flow increases with the upward movement of the cap 2 to the full open position, even though the opening at its maximum may be only $\frac{1}{1000}$ of an inch, the turbulence from the increased rate of flow still further increases so as to effectively prevent any traces of stringiness of the conical spray discharge throughout the duration of each such discharge. The spray is found to emerge in the form of a fine mist which is discharged uniformly all around the nozzle, indicating that the streams from the passages 9 have completely lost their individual identities in the cavity 18 before escaping between the surfaces 7 and 10. Thus the cavity 18 performs the dual function of maintaining a supply of liquid fuel adjacent the orifice available for instant delivery without a time lag after the opening of the valve, and also, of creating a turbulence under flow conditions which breaks up the individual streams of fuel and prevents stringiness of the discharge.

Another feature of novelty in the present nozzle is the manner of overlapping the rim 10a of the cap 2 upon the rim 19 on the body 1 to keep the region of the orifice free of objectionable carbon deposits. As shown in the drawings, this overlapping is produced by making the diameter of the rim of cap 2 slightly greater than the diameter of the body 1. By keeping the orifice free

of carbon accumulations, the spray will not become stringy after continued use of the nozzle, but will always be disposed uniformly around the orifice in a fine mist, which is the ideal condition sought. Although carbon accumulations are presumably not encountered in manifold injections, it is advantageous to make the nozzle suitable also for cylinder head injection where carbon deposits must necessarily be reckoned with. An adaptation especially for head injection will presently be described in connection with Fig. 5.

A strainer 20 is carried upon a strainer pin 21 having on one end thereof an eye 22 through which may be passed a locking pin 23 received in apertures 24 in the body 1.

Fig. 4 shows the manner of mounting the nozzle of Fig. 1 in an intake manifold 29. The threaded portion 3 of the body 1 may be carried by an upstanding tubular element 30 on a hollow strut or pipe 31 carried within the manifold 29. The tubular element 30 is provided with an interior chamber 32 adapted to house the strainer 20, which chamber communicates with the fuel passage 33 leading to an external fuel connection 34.

The apex angle A of the conical spray 15 in the embodiment shown in Figures 1 to 4 is illustrated as being 90°, but it is understood that this angle is illustrative only and that any other suitable angle may be used.

In Fig. 4, the nozzle is mounted in an upright position to spray in the direction of the air flow, but it is to be understood that it is also within the scope of the invention to produce the fuel injection in the opposite direction from the air flow in the manifold.

Fig. 5 shows a modified nozzle constructed according to the present invention, and particularly adapted for cylinder head injection. A typical cylinder head is represented at 40, having valves 41 and cooling fins 42. In this embodiment, a bushing 43 is secured in the cylinder head 40 to mount the fuel injector nozzle in the desired position with respect to the cylinder and the valves 41. Parts corresponding to parts shown in Fig. 1 have been supplied with primed reference numerals corresponding to the reference numerals used in Fig. 1.

A body 1' having passages 9', and carrying the cap 2', is secured tightly against a gasket or packing ring 44 by means of the threaded ring 45. Because of space limitations on the typical cylinder head, it is usually preferable not to provide a strainer on the nozzle, and so the rear part of the nozzle in Fig. 5 has been modified to reduce the protuberance extending from the cylinder head. Fuel is admitted to the chamber 4' through a plurality of openings 46 in a tubular element 47 which is provided with a head 48 and has threaded engagement with the body 1' at 49. An annular shell 50 surrounds the tubular element 47 to provide an annular chamber 51 communicating with the openings 46 and the fuel supply connection 52. The fuel strainer may be placed at any convenient point in the fuel line leading up to the connection 52.

The operating parts of the nozzle in Fig. 5 correspond to the nozzle in Fig. 1, except that it will be noted that the cap 2' is provided with a flattened head so as to substantially conform to the inner contours of the cylinder head 40. The chamber 4', passages 9' and cavity 18' are supplied with fuel by the fuel injection pump in the same manner as in the device of Fig. 1, and the

operation of the injector is also the same. The lift of the cap 2' has been greatly exaggerated for clearness, in the drawings.

When the fuel-pressure reaction becomes sufficient to compress the spring 11' and lift the cap 2', the supply of fuel in the cavity 18' will immediately initiate a spray as shown at 15'. During injection the high velocity streams in the passages 9' will impinge upon the curved surface of the cavity 18' to break up the individual flows by great turbulence and produce the desired uniformity in the conical spray 15', free from unevenness and stringiness. The apex angle B of the spray cone 15' is illustrated as being approximately 45° to avoid contact with the valves 41, but it is understood that this angle may be varied to suit any particular installation.

The rim of the cap 2' slightly overlaps the conical surface on the body 1' on which it seats to prevent the accumulation of carbon deposits, as described in connection with the overlapping of the rim 10a upon the rim 19 in the embodiment of Fig. 1. To insure the effectiveness of this overlapping construction in preventing the accumulation of carbon, the lower part of the bushing 43 and the gasket 44 should be cut back to clear the cap 2' and the cone of spray issuing from under the cap.

While two modifications of the present injector nozzle are shown for purposes of illustration, it is to be understood that the invention is capable of other modifications, and that changes in the construction and arrangement may be made which do not depart from the spirit and scope of the invention as defined by the appended claims.

Having now described my invention and the manner in which the same may be used, what I claim and desire to secure by Letters Patent is:

1. In a fuel injector nozzle for internal combustion engines, a nozzle body having a conical surface formed therein, a cap having an unbroken conical surface extending continuously from the outermost peripheral extremity of said cap inwardly toward the axis thereof and adapted to seat on said first named surface to form a liquid pressure seal and adapted to lift off said first named surface to form a conical spray orifice, said conical surfaces when seated one upon the other being arranged to lie on the surface of a common cone having its apex in said body and when slightly separated one from the other being adapted to produce a conical spray discharge conforming to said common cone, an annular cavity in said cap the outer wall of which cavity is defined by the inner extremity of the conical surface of said cap, said cavity being adapted to hold a substantial quantity of liquid fuel adjacent said surfaces when said cap is seated, and means in said body to direct a plurality of fine streams of fuel into said cavity to break up said streams and insure an even spray.

2. In a fuel injector nozzle for internal combustion engines, a body having a recess in one end thereof, a cap having a lip adapted to fit into said recess and form a liquid pressure seal when said cap is seated, said recess and said lip having abutting conical surfaces lying in the surface of a common cone having its apex in said body, the conical surface of said lip extending continuously from the outermost peripheral extremity of said cap inwardly toward the axis thereof, said wall and said lip forming a conical spray orifice when said cap is unseated, said orifice being thereby adapted to produce a conical spray discharge conforming to said common cone, an annular

cavity in said cap the outer wall of which cavity is defined by the inner extremity of the conical surface of said cap, said cavity cooperating with the recess in said body to hold a substantial quantity of fuel adjacent said lip for instantaneous injection when said cap is caused to be unseated, and means for directing a stream of fuel into the cavity in said cap to break up said stream and insure an even spray.

3. A fuel injector nozzle for internal combustion engines comprising a cylindrical body, an axial opening through said body, a conical surface coaxial with said body and extending into one end thereof to form a shallow chamber in said end, a cap having a stem slidably received in said axial opening, said cap having a conical surface extending continuously from the outermost peripheral extremity of said cap inwardly toward the axis thereof and shaped to closely fit into the conical surface in said body and having an annular recess between said conical surface and said stem, and a plurality of longitudinal orifices through said body and terminating in said shallow chamber, said orifices being directed toward the annular recess in said cap, the conical surfaces on said body and said cap lying on the surface of a common cone having its apex in said body and being thereby adapted to produce a spray discharge conforming to said common cone.

4. A fuel injector nozzle for internal combustion engines comprising a cylindrical body, an axial opening through said body, a conical surface coaxial with said body and extending into one end thereof to form a shallow chamber in said end, a cap having a stem slidably received in said axial opening, said cap having a lip with a conical surface extending continuously from the outermost peripheral extremity of said cap inwardly toward the axis thereof and closely fitting said first named surface to form a valve for interrupting the escape of fuel when said surfaces are caused to abut and to form an annular spray orifice when said surfaces are separated, said abutting surfaces lying on the surface of a common cone having its apex in said body whereby the separation of said surfaces is adapted to produce a spray discharge conforming to said common cone, an annular recess in said cap to cooperate with said shallow chamber to confine a substantial quantity of fuel under pressure adjacent said valve surfaces for instantaneous injection when said surfaces are first separated, the outer wall of said recess being defined by the inner extremity of the conical surface of said cap, and a plurality of orifices in said body for projecting fine streams of fuel into said recess as fuel escapes therefrom when said surfaces are separated for injection.

5. In a fuel injector nozzle for internal combustion engines, a nozzle body having a conical surface formed therein, a cap having a conical surface adapted to seat on said first named surface to form a liquid pressure seal and adapted to lift off said first named surface to form a conical spray orifice, said surfaces lying on the surface of a common cone whereby the separation of said surfaces is adapted to produce a spray discharge conforming to said common cone, said surfaces seating in overlapping relationship with said cap surface overlapping said body surface to prevent the accumulation of carbon deposits, a cavity in said cap adapted to hold a substantial quantity of liquid fuel adjacent said surfaces when said cap is seated, and means in

said body to direct a plurality of fine streams of fuel into said cavity to break up said streams and insure an even spray.

6. A fuel injector nozzle for internal combustion engines comprising a cylindrical body, an axial opening through said body, a conical surface formed in said body, a cap having a stem slidably received in said opening, said cap having a conical surface adapted to seat on said first named surface to form a liquid pressure seal and adapted to lift off said first named surface to form a conical spray orifice, said surfaces lying on the surface of a common cone whereby the separation of said surfaces is adapted to produce a spray discharge conforming to said common cone, said surfaces seating in overlapping relationship with said cap surface overlapping said body surface to prevent the accumulation of carbon deposits, a cavity in said cap adapted to hold a substantial quantity of liquid fuel available for instant release when said cap is lifted, and a plurality of orifices in said body for projecting fine streams of liquid fuel into said cavity to break up said streams and insure an even spray.

7. A fuel injector nozzle for internal combustion engines comprising a cylindrical body, an axial opening through said body, a conical surface formed in said body, a spring loaded cap having a stem slidably received in said opening, said cap having a conical surface adapted to seat on said first named surface to form a liquid pressure seal and adapted to lift off said first named surface to form a conical spray orifice, said surfaces lying on the surface of a common cone whereby the separation of said surfaces is adapted to produce a spray discharge conforming to said common cone, said surfaces seating in overlapping relationship with said cap surface overlapping said body surface to prevent the accumulation of carbon deposits, a cavity in said cap adapted to hold a substantial quantity of liquid fuel available under pressure for instant release when said cap is lifted, an orifice in said body for projecting a stream of liquid fuel into said cavity to break up said stream and insure an even spray, and adjustable means for limiting the maximum width of said spray orifice.

8. A fuel injector nozzle for internal combustion engines comprising a cylindrical body, an

axial opening through said body, an axial chamber in one end of said body, a coaxial conical surface formed in the other end of said body, a spring loaded cap having a stem slidably received in said opening, said cap having a lip with a conical surface extending continuously from the outermost peripheral extremity of said cap inwardly toward the axis thereof and adapted to seat on said surface to form a liquid pressure seal and adapted to be lifted by fuel pressure to form a conical spray orifice, said conical surface on said body and said conical lip on said cap lying on the surface of a common cone whereby the separation of said parts is adapted to produce a conical spray discharge conforming to said common cone, an annular cavity in said cap the outer wall of which cavity is defined by the inner extremity of the conical surface of said cap, said cavity being adapted to retain a substantial quantity of liquid fuel under pressure adjacent said lip for instant release when said cap is lifted, a plurality of longitudinal orifices through said body for directing a plurality of fine streams of liquid fuel into the cavity in said cap, and means for limiting the amount of lift of said cap.

9. A fuel injection nozzle for internal combustion engines comprising a cylindrical body, an axial opening through said body, an axial chamber in one end of said body, a coaxial right circular conical surface formed in the other end of said body, a cap having a stem slidably received in said opening, said cap having a coaxial lip of like right circular conical shape extending continuously from the outermost peripheral extremity of said cap inwardly toward the axis thereof and adapted to seat on said first surface to form a liquid pressure seal and adapted to be lifted from said surface to form a like right circular conical spray orifice, an annular cavity in said cap the outer wall of which cavity is defined by the inner extremity of the conical surface of said cap, said cavity being adapted to retain a substantial quantity of liquid fuel under pressure adjacent said lip for instant release when said cap is lifted, and a longitudinal orifice through said body for directing a stream of liquid fuel into the cavity in said cap.

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