

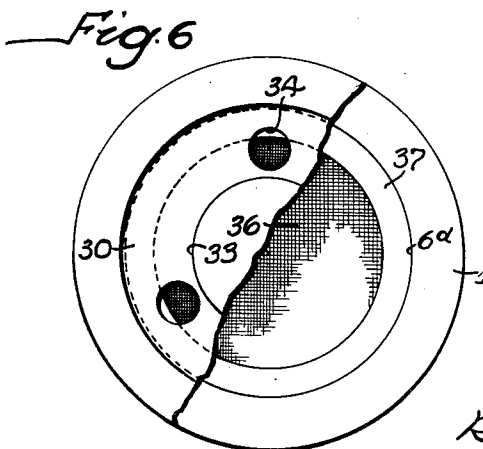
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FUEL INJECTION NOZZLE

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2,602,005

FUEL INJECTION NOZZLE

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mesne assignments, to American Bosch Corpo-
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1 Claim. (Cl. 299—107.6)

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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 objects of the invention is to provide a novel fuel injection nozzle which is efficient in operation over the entire speed and load range of the engine, and which in particular will inject a fuel spray having adequate penetration.

Another object is to provide a new and improved fuel injection nozzle which has good fuel spray characteristics, and which will retain such characteristics when subjected in use to heat and carbon.

A further object is to provide a novel fuel injection nozzle which has a high discharge velocity, which is substantially free from the formation of carbon and in which there is a free flow of the fuel to the injection orifice.

Another object is to provide a new and improved fuel injection nozzle of the outwardly opening pintle type in which the discharge bore and the pintle are correlated in shapes and proportions to obtain and maintain desired fuel penetration.

A further object is to provide a fuel injection nozzle having a novel adapter which may be used or omitted to facilitate mounting the nozzle interchangeably in different types of existing holders.

Another object is to provide a new and improved fuel injection nozzle having an oil filter of simple and inexpensive construction.

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

In the accompanying drawings:

Figure 1 is a longitudinal axial sectional view of a fuel injection nozzle and filter embodying the features of my invention.

Fig. 2 is a fragmentary end view of the nozzle showing the discharge orifice.

Fig. 3 is a fragmentary axial sectional view of the nozzle tip on an enlarged scale.

Fig. 4 is a fragmentary perspective view of a valve member forming part of the nozzle.

Fig. 5 is a transverse sectional view taken along line 5—5 of Fig. 3.

Fig. 6 is a fragmentary view of the mounting end of the nozzle.

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 dis-

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closed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring more particularly to the drawings, the fuel injection nozzle constituting the exemplary embodiment of my invention is of the general type disclosed in a copending application by James F. Hoffer, Serial No. 259,088, filed March 1, 1939, Patent No. 2,351,965, having an outwardly opening valve adapted to open and close with a popping action.

The nozzle comprises a body 1 adapted to contain all of the operating parts, and to be removably mounted as a replaceable unit in a suitable holder 2 partially shown in dotted outline (Fig. 1). Preferably, the body 1 is in the form of a tubular shell or casing having an external peripheral mounting flange 3 on the base end. To secure the nozzle unit endwise against the holder 2, a nut 4 is threaded on the latter, and has an internal flange 5 engaging over the mounting flange 3. It will be understood that the holder and nozzle assembly is adapted to be clamped or otherwise secured to an internal combustion engine (not shown) with the nozzle tip positioned to discharge a jet or spray of fuel into the combustion chamber.

The nozzle tip body 1 is made preferably in an integral or one-piece construction, and is formed in the base end with a stepped bore 6 constituting an inner chamber, and in the outer end with an axial discharge passage or bore 7 opening to the exterior. The bore 6 comprises sections of varying diameters, including an inner section 6^a serving as a spring pilot, an intermediate section 6^b of slightly larger diameter, and an outer section 6^c of still larger diameter serving as a guide, as hereinafter more fully described. Formed in the bore 6 intermediate the sections 6^b and 6^c is an internal peripheral groove 8, one side of which defines an outwardly facing annular shoulder 9. A counterbore 6^d of comparatively large diameter is formed in the base end of the body 1.

Fuel under pressure is adapted to be supplied from a suitable source (not shown) through the holder 2 to the inner chamber 6 of the nozzle body 1. During periods of injection, the fuel is permitted to flow from the chamber 6 through and under the control of a normally spring-seated valve 10. In the present instance, the valve 10 comprises an inlet passage 11 connecting the chamber 6 to the discharge bore 7, and formed at its outer end with a stationary annular

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valve seat 12. A movable valve member 13 is reciprocable axially of the discharge bore 7, and is formed with an annular valve face 14 adapted for engagement with the seat 12.

The valve member 13 has an axial stem or shank 15 which extends in free peripherally-spaced relation through the valve passage 11 to define therewith an annular path of fuel flow, and then inwardly into the bore or chamber 6. Suitable spring means, such as a coil compression spring 16, acts on the inner end of the stem 15 in a direction to urge the valve member 13 inwardly toward or in closed position with a predetermined force.

The spring 16 encircles the valve stem 15, and impinges at one end against the inner end face of the bore section 6^a which serves as a pilot for this end of the spring. The other end of the spring 16 impinges against a movable hanger 17 removably anchored to a head 18 on the inner end of the valve stem 15. More particularly, the hanger 17 consists of an elongated guide sleeve slidable in the bore section 6^a, and having intermediate its ends an inner transverse wall 19 formed with a slot 20 in interlocking engagement with the head 18.

The valve 10 has an effective opening pressure area which is exposed to the pressure of the fuel within the chamber 6, and which is substantially equal to the area circumscribed by the stationary annular valve seat 12. When the valve 10 is in closed position, the flow of fuel to the discharge bore 7 for injection is blocked, and the hanger sleeve 17 is spaced inwardly from the annular shoulder 9. When the pressure of the fuel acting on the opening pressure area is sufficient to overcome the closing force of the spring 16, the valve member 13 is lifted outwardly from the seat 12 to open the valve 10 and start injection. The maximum height of rise of the valve member 13 is limited by engagement of the hanger sleeve 17 with the fixed stop shoulder 9.

A spray control pintle 21 is formed integral with and projects outwardly from the valve member 13. The pintle 21 extends slidably through the discharge bore 7, and coacts with the outer end thereof to define an annular discharge orifice 22. By selective choice and variation in the form of the bore 7 and the pintle 21, fuel sprays of different characteristics are obtainable. In the present instance, the discharge bore 7 is formed with a narrow inner cylindrical land area 23, conveniently termed a body land, at the extreme outer end, and with an inclined peripheral undercut 24, defining a conical bore section tapering outwardly to the body land. Thus, the undercut converges symmetrically with respect to the axis of the discharge bore 7 toward and merges into the body land 23. At the inner end of the inclined body undercut 24, the bore 7 is formed with an annular rib 25 for guiding the pintle 21, and inwardly of the rib, the bore is formed with a cylindrical undercut 26 to permit flow of fuel past the valve member 13 while the valve member is unseated. The pintle 21 is formed with a narrow cylindrical land area 27, conveniently termed a pintle land, of full pintle diameter, at the extreme outer end, and a control cone 28 tapering inwardly therefrom. When the valve 10 is closed, the pintle 21 is fully retracted, and the pintle land 27 is located within the body land 23. Upon opening movement of the valve 10, the pintle 21 is projected out of the body 1, and the control cone 28, in moving across the outer peripheral edge of the body land 23,

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provides an injection orifice 22 of progressively increasing area.

Inwardly of the tapered control cone 28, the pintle 21 is generally cylindrical in form, and in guiding engagement with the rib 25. Suitable flats 29 are formed in the sides of the cylindrical portion of the pintle 21, four such flats being shown, to provide passages for the free flow of fuel from the valve 10 past the rib 25 to the injection orifice 22.

The efficiency of operation, and the characteristics of the fuel spray issuing from the nozzle are influenced by certain critical factors involving the relative shapes, angles and dimensional proportions of the discharge bore 7 and the pintle 21.

The four flats 29 which define the downflow passages along the pintle 21, as compared to a lesser number, tend to prevent or minimize division of the fuel spray into separate jets, the fuel recombining more readily in the region of the control cone 28.

The width of the pintle land 27 has a direct effect on the form of the spray. In general, a comparatively narrow land results in a soft spray, and a relatively wide land in increased penetration. The width of the land 27 may be varied in practice depending on the spray characteristics desired, but such variation is confined within certain practical limits for best results. If the land is too narrow, difficulties may be encountered in obtaining the desired popping action of the valve 10 in its accelerated opening and closing movements. As more fully explained in the aforesaid application, this popping action is obtained because the effective transverse area of the pintle 21, exposed to the pressure of the fuel when the valve 10 is open, is larger than the valve opening pressure area. If the pintle land 27 is too wide, the valve opening may be accelerated to such an extent that the pintle is subjected to undue stress, and an excessive dash-pot action may result on valve closing. Satisfactory results are obtainable if the width of the pintle land 27 is confined to a range of from .001 to .015 inch. When a soft or low penetrating spray is desired, a width of pintle land within a range of from .002 to .005 inch may be advantageously used. For a high penetrating spray, a land having a width within a range of from .003 to .015 inch may be advantageously used.

The distance of the inclined body undercut 24 from the outer end face of the body 1 determines the width of the body land 23, and influences the extent to which the spray penetration characteristics are retained in continued use. This land circumscribes the pintle land 27 when the valve 10 is closed or nearly closed, and coacts with the pintle 21 to effect a smooth flow of fuel to the outlet of the discharge or injection orifice 22. If the body land 23 is considerably wider than the pintle land 27, carbon tends to form thereon and interfere with the smooth flow of fuel. If the body land 23 is increased to an excessive width, the fuel spray will be unduly soft and lack the desired degree of penetration. Satisfactory results are obtainable if the width of the body land 23 is confined within a range of from .005 to .030 inch. The preferred width of the body land 23 is approximately .013 inch, which imparts a smooth flow to the fuel and gives excellent penetration, and which, being only slightly greater, if greater at all, than the width

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of the pintle land 27, leaves a minimum area exposed to carbon formation.

The inclined body undercut 24, which converges from the guide rib 25 toward the body land 23, is an important factor in obtaining a penetrating spray, and the length, depth and angle to the nozzle axis all have a controlling influence. The converging surface of the undercut 24, in cooperation with the diverging surface of the control cone 28, serves to direct the fuel smoothly and at progressively increasing velocity to the discharge orifice 22. The included angle between the bottom surface of the undercut 24 and the axis of the pintle 21 should be between 5° and 25° for satisfactory results. The preferred angle is 11°, so that the undercut will have ample length without undue depth.

The maximum depth of the undercut 24 is also confined between preferred limits. If the depth is too great, the undercut is deprived of effectiveness. If, for a given included angle, the depth is too shallow, the undercut will not be of sufficient length to influence the spray properly for best penetration. Satisfactory results are obtainable if the radial depth of undercut is confined within a range of from .001 to .010 inch. Preferably, an undercut 24 having a maximum depth of .0045 inch is employed. If the undercut 24 is inclined at an angle and provided with a suitably selected depth, respectively within the ranges therefor specified herein, it will also have ample length to influence the characteristics of the fuel spray in the manner and to the extent desired.

The penetration of the fuel spray is also influenced by the cone angle and the degree of lift of the pintle 21. For maximum penetration, a cone angle of from 7° to 10° is employed.

It is desirable to confine the lift or height of rise of the pintle 21 between certain limits so as to retain a relatively small orifice area and thereby insure a high velocity of fuel discharge. The height of rise is related to the maximum rate of discharge which in turn is a function of the engine size, speed and duration of the injection period for a given quantity of fuel. Preferably, the lift or height of rise of the pintle is limited to a distance within a range of from .020 to .050 inch, a rise of .035 inch being suitable in most instances. The maximum height of rise is thus limited positively in conformity with the maximum rate of fuel delivery required in a given instance, but it is to be understood that the actual height of rise of the pintle may be less than the permissible maximum, and will be self-adjustable to develop the necessary orifice flow area for a given rate of fuel delivery required under particular operating conditions, as for example, when the engine speeds and loads are reduced.

The nozzle is provided with an adapter 30 which may be used or omitted as required to facilitate mounting the body 1 interchangeably in different types of holders. The adapter consists of a circular plate adapted to be seated against the base end of the body 1, and formed on its inner face with a circular projection 31 having a snug press fit in the counterbore 6^d. Preferably, the circular projection 31 is peripherally undercut, as indicated at 32, thus providing substantially line contact with the inner surface of the counterbore 6^d and a degree of flexibility to insure a good press fit. The outer face of the adapter 31 is formed with an annular

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groove 33 opening through a bore 34 to the counterbore 6^d and adapted for communication with the fuel supply passage in the holder.

In use, when the adapter 30 is removed, the mounting flange 3 alone is secured to the holder by means of the nut 4, and fuel is supplied directly to the counterbore 6^d and thence to the inner chamber 6 of the body 1. For other types of holders, the adapter 30 is inserted in position against the base end of the body 1, thus adding to the width of the mounting flange 3. In this case, both the body flange 3 and the adapter 30 are secured to the holder by the nut 3, and the annular groove 33 is disposed in registration with the fuel inflow passage of the holder.

Inserted in the bottom of the counterbore 6^d, with a press fit, is a fuel filter 35. In its preferred form, the filter 35 comprises a filtering screen 36 which may be of laminated construction and which is secured at the periphery by a rim 37 rounded at its outer peripheral edge for snug yieldable engagement with the inner peripheral surface of the counterbore 6^d.

In operation, fuel under pressure is supplied to the inner chamber 6. The pressure acts on the opening area of the valve 10, and when the force is sufficient to overcome the pressure of the spring 16, the valve will open to start injection. After the initial opening movement, the full diameter of the pintle 21 will be subjected to the fuel pressure, and since the effective pintle area is larger than the valve opening area, the valve will continue to open with an accelerated or popping action. In the opening movement, the pintle 21 is guided by the rib 25. From the valve 10, the fuel passes along the flats 29 and then is directed by the inclined undercut 24 and the control cone 28 to the injection orifice 22 from which it issues at a high velocity in a narrow penetrating spray.

I claim as my invention:

In a fuel injection nozzle, in combination, a hollow body having a fuel inlet passage in communication with one end and a discharge bore opening axially to the other end, said discharge bore being formed with a narrow inner cylindrical body land at the extreme outer end and with an inclined undercut converging toward said land, a valve controlling communication between said passage and said bore and comprising an outwardly facing annular valve seat formed in said passage in axial alignment with said bore, a valve member reciprocable in said bore and having an annular valve face adapted for engagement with said seat, and spring means acting on said valve member in a direction to urge said member toward said seat, a cylindrical undercut in said bore to permit the flow of fuel about said valve member when said valve is open, an inner peripheral guide rib formed in said bore between said undercuts, a pintle rigid with said valve member and slidably guided in said rib, said pintle coacting with the outer edge of said bore to define an annular discharge orifice having a narrow cylindrical land at the extreme outer end and a symmetrical control cone tapering inwardly from the pintle end, said pintle being formed in the sides and inwardly of said control cone with longitudinal flats defining downflow passages from said valve past said rib to said inclined undercut.

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