Jan. 11, 1944. O. E. SZEKELY 2,338,744

INJECTION NOZZLE FOR INTERNAL COMBUSTION ENGINES

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Fig. 1,

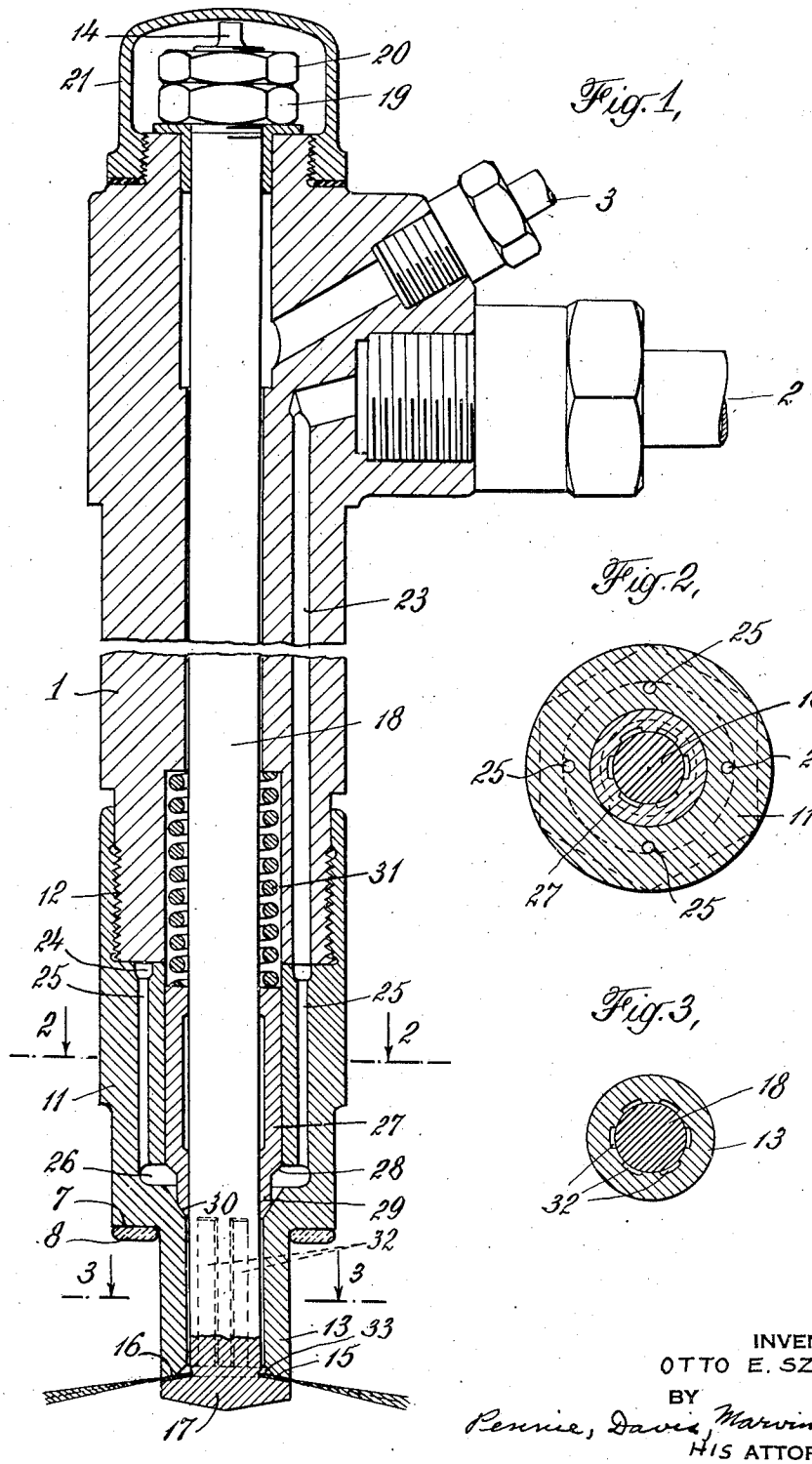


Fig. 2,

Fig. 3,

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Fig. 4,

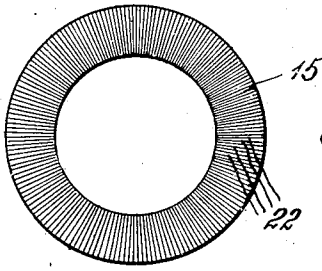


Fig. 5,

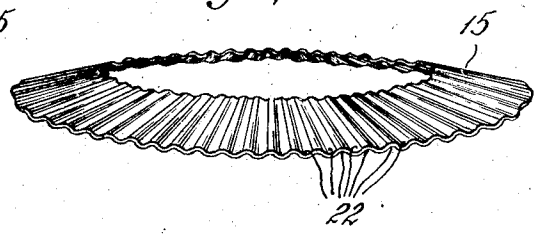
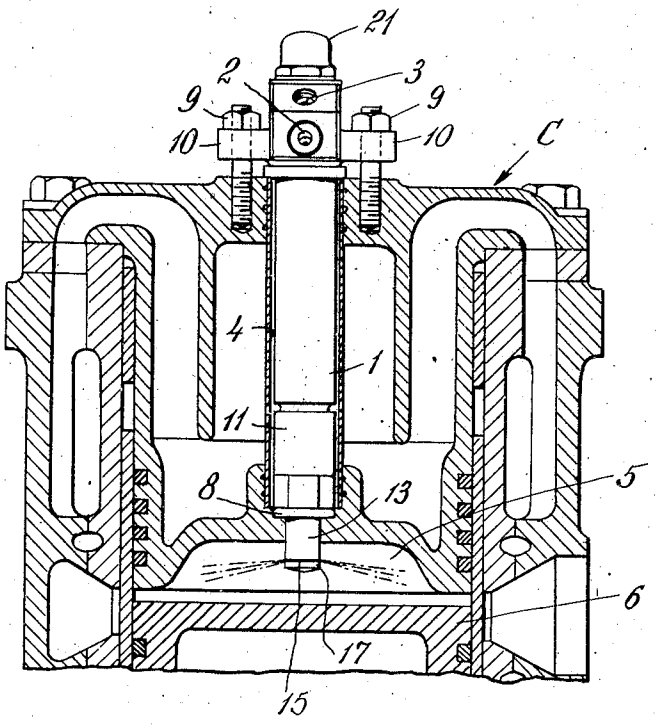


Fig. 6.



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UNITED STATES PATENT OFFICE

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INJECTION NOZZLE FOR INTERNAL COMBUSTION ENGINES

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Application August 26, 1941, Serial No. 408,337

15 Claims. (Cl. 299—107.3)

This invention relates to improvements in liquid fuel injection nozzles for internal combustion engines.

In the operation of internal combustion engines of the compression ignition type it is important to obtain proper combustion of the fuel within the cylinder and smooth operation of the engine. In order to provide the optimum conditions for combustion, the atomization of the fuel and its penetration into the charge of compressed air within the cylinder must be such as to provide as large an exposed liquid surface as possible. This also contributes to smooth operation, that is, freedom from vibration and ignition knock. In a multi-cylinder engine smoothness of operation depends, to a large degree upon (1) the uniformity of the combustion characteristics of the several cylinders (the combustion characteristics determining the proper rate of pressure rise) and (2) uniformity of quantity of fuel injected into the several cylinders. At present, however, such uniformity is difficult of attainment because of variations between the injection valves of the individual cylinders caused by the necessary manufacturing tolerances. Hence, although the injection valves of all of the cylinders of a given engine are as nearly alike as it is practical to make them, their spray characteristics may vary sufficiently to cause one or more of the cylinders to produce a smoky exhaust due to improper combustion and, perhaps, variation in the quantity of fuel injected at each stroke of the injection pump. As a result, the engine may vibrate to a considerable extent or produce what is known as "rough" operation.

The present invention aims to overcome these difficulties by providing a fuel injection nozzle whose spray characteristics are capable of adjustment while the engine is in operation.

Another object of the invention is to provide a fuel injection nozzle which is capable of producing a fuel spray having an extraordinarily large area exposed to the charge of air within the cylinder.

In the operation of internal combustion engines of the compression ignition type, it is a common experience to have the fuel injection nozzles become clogged with carbon deposit, and a further feature of my present invention is the provision of a fuel injection nozzle in which the tendency to clog is largely eliminated but in which, if clogging occurs, the deposit causing the clogging can be removed without stopping the engine or substantially reducing its load or speed.

A still further aim of the invention is to provide a fuel injection nozzle whose movable parts are removed from the zone of intense heat so that their proper operation is not interfered with.

The inventive idea is capable of mechanical expression in a number of different forms. For the purpose of illustrating the invention, one of these is shown in the accompanying drawings but it is to be understood that such drawings are for the purpose of illustration only and are not intended to define the limits of the invention, the scope of which is indicated in the accompanying claims. From a consideration of these drawings, together with the following description, the invention will be understood.

In these drawings:

Fig. 1 is a longitudinal section taken centrally through the improved injection nozzle;

Fig. 2 is a transverse section taken in the plane indicated by line 2—2 of Fig. 1;

Fig. 3 is a transverse section taken in the plane indicated by line 3—3 of Fig. 1;

Figs. 4 and 5 are, respectively, a top view and a perspective view of one of the elements of the nozzle, Fig. 5 being drawn to a greatly enlarged scale.

Fig. 6 is a central longitudinal section of the cylinder head and upper portion of a cylinder of an internal combustion engine of the compression-ignition type showing the improved injection nozzle in operating position.

Referring now to these drawings, and more particularly to Figs. 1 and 6, the improved nozzle comprises an elongated body or housing 1 having at its inner end a tip or spray-producing device and at its outer end the usual fuel supply line connection 2 and fuel bleed line connection 3. The length of the nozzle is sufficient to extend through the nozzle-receiving opening 4 in the cylinder head so as to position the nozzle tip within the compression space or chamber 5 which, in the engine illustrated in Fig. 6, is formed between the upper surface of a cavity in the cylinder head or cover C and the top of the engine piston 6 when it is at the upper end of its stroke.

The nozzle is provided near its lower end with a sealing shoulder 7 on which is placed the usual gasket 8, and the nozzle is held in place, with this gasket firmly pressed against a suitable shoulder in the cylinder head C, by means of nuts 9 cooperating with lugs 10 at the outer end of the nozzle. The shoulder 7 is formed on a removable section 11 of the nozzle body which is secured

to the inner end of the main body section 1 by threads 12. At the lower end of removable section 11 there is projection 13 of reduced diameter which passes through the wall of the cylinder head C and at its inner end carries the nozzle tip from which the fuel is sprayed.

This tip or spray-producing device consists of a radially corrugated annular member or washer 15 of resilient material such as a steel alloy which will retain its resilient characteristics at the high temperatures to which it is subjected. This member may be flat or slightly dished, that is, slightly conical, as shown in Figs. 1 and 5, and is clamped between an annular shoulder 16 at the end of projection 13 and a complementary head 17 which is formed on the inner end of a rod 18 extending through a central bore from end to end of the nozzle body sections 1 and 11. Rod 18 forms an adjusting member for adjusting the spray characteristics of the nozzle tip and is provided at its outer end with an adjusting nut 19 and a lock nut 20. The extreme outer end 14 of rod 18 is milled flat so that the rod can be held from turning while adjusting nuts 19 and 20. The outer end of rod 18 and these nuts are enclosed within a cover 21 threaded onto the outer end of the nozzle.

The adjustment of the nozzle tip is accomplished by compressing to a greater or less degree the resilient nozzle ring 15 by turning the adjusting nut 19 so as to compress the ring between the head 17 and the shoulder 16. This alters the depth of the radial corrugations 22 in the upper and lower surfaces of the ring 15 which, with the surface of the coacting shoulders, form the fuel spray passages.

Corrugations 22 are small radial depressions or grooves so close to one another that the fuel issues from the nozzle tip in the form of a thin annular sheet or cone of liquid extending continuously around the tip. The thickness of the annular tip ring 15, the spacing or fineness of the radial depressions or corrugations and the contour of these corrugations can be varied to produce the range of variation of thickness and diameter of the annular ring or cone of fuel desired under any particular operating conditions, such, for example, as compression pressure, liquid fuel pressure, diameter of cylinder, shape of compression or combustion space, etc.

By turning the adjusting nut 19 on its outer end externally of the engine cylinder, the spray characteristics such as the penetration, atomization, shape of the fuel spray and quantity of fuel can be varied to suit the characteristics of the particular cylinder with which the nozzle is operating so as to obtain optimum combustion conditions or characteristics.

The fuel entering the nozzle through the supply line connection 2 flows through a passage 23 in the nozzle body to an annular distributing groove 24 formed in the upper portion of removable body section 11. Arranged around this distributing groove, as shown in Fig. 2, there are a plurality (in this instance, 4) of small drilled fuel ducts 25 which convey the fuel to a second annular distributing groove 26 at the lower end of a check valve member 27. The lower end of this valve member is reduced in diameter to provide an annular area 28, on which the pressure of the liquid fuel within channel 26 operates to lift the valve member 27 and its conical end 29 off from the valve seat 30, formed within body section 11 just below chamber 26. Valve member 27 is slidable on rod 18 and is urged against seat 30 by means of a helical spring 31.

When the valve is lifted away from its seat the fuel from annular channel 26 passes downwardly around the lower end of rod 18 to tip ring 15. To maintain the head 17 accurately centered with respect to ring 15 and the end of projection 13, and, at the same time, provide for passage of the fuel, the opening in projection 13 through which rod 18 passes is formed as shown in Fig. 3 with longitudinal splines or channels 32 distributed in equally spaced relation around the circumference of rod 18. The upper ends of splines 32 open into the valve seat 30 and their lower ends terminate in a third annular channel 33 at the inner edge of nozzle ring 15. Because of the presence of the three transverse distributing channels 24, 26 and 33 and their interconnecting sets of ducts 25 and 32, respectively, the fuel is equally distributed around ring 15.

As is common practice with injection valves, the leakage fuel is led back through bleed line 3 to the fuel tank. In the present nozzle, however, provision is made for a definite proportion of leakage to the quantity of fuel injected. This is provided for by making the upper and lower end portions of valve member 27 closely fit the surface of rod 18 with a predetermined clearance. These clearance surfaces therefore act to meter the flow of bleed fuel in proportion to the injection pressure and the adjustment of nozzle spray tip, a comparatively large clearance space being provided between the surface of rod 18 and the central bore in the nozzle body 1 so that the bleed fuel may flow freely up to the bleed line connection 3.

It will be understood that the improved injection nozzle can be used with a separate fuel pump for each nozzle, that is to say, for each engine cylinder, or with a single or common fuel pump supplying all the cylinders. Furthermore, the fuel pump can be separate from the nozzle and connected thereto by a supply pipe line as described above, or, when a separate fuel injection pump is provided for each cylinder, the improved injection nozzle can be made integral with the fuel pump.

By the nozzle construction of the present invention, there has been provided a means by which the combustion characteristics of each cylinder of a multi-cylinder internal combustion engine can be adjusted independently of all of the other cylinders. It is possible easily and quickly to adjust the operation of each cylinder of the engine until the engine as a whole is operating smoothly and with maximum economy of fuel, which can be determined by the condition of the engine exhaust and the smoothness of operation, or by measurement of the exhaust temperature from the individual cylinders.

Furthermore, although there is less danger of the accumulation of deposits in the nozzle causing clogging, when each cylinder of the engine is operating under optimum combustion conditions, should such clogging take place, it can be relieved without shutting down the engine, or even substantially reducing the load which the engine is carrying. This is done by turning adjusting nut 19 several times first in one direction and then in the opposite to compress and release spray ring 15, thereby dislodging whatever material may have been deposited in the fuel passages of the nozzle. Thereupon the nozzle may again be adjusted to give the proper combustion within the cylinder.

In addition to the above advantages, the continuous annular sheet or cone of fuel issuing from the multiplicity of small openings around the tips penetrates the compressed air charge within the cylinder in the form of a continuous annular sheet composed of innumerable particles forming a mist or fog. The atomization of the fuel thus produced is more complete and the combined areas of the surfaces of the fuel particles exposed to the air charge is substantially greater than is the case with nozzles of the jet type. This larger exposed surface of the spray results in smoother combustion and smoother operation of the engine as well as in converting an increased percentage of the heat units of the fuel into work, or, in other words, improving the fuel economy of the engine.

Still another advantage of the improved nozzle construction is the fact that the check valve member 27 is removed from the zone of highest temperature of the nozzle since it is disposed outwardly from the tip a substantial distance, and, because of this, it is not apt to stick, either from possible temperature differences between the valve member and its surroundings or because of deposits accumulating on the valve surfaces.

While the invention has been described with a considerable degree of particularity, there are many changes from the specific construction described that may be made without departing from the principle or inventive idea involved, and the appended claims are intended to define not only the specific nozzle construction described above, but also all such modifications thereof as may fall within the scope of these claims.

I claim:

1. An injection nozzle for internal combustion engines having a spray-producing device comprising a radially corrugated annular resilient member, opposed surfaces coacting with the opposite faces of said member to form with the corrugations thereof fuel passages, and means for adjusting said surfaces with respect to one another to compress said member to varying degrees so as to vary the spray characteristics of said device.

2. In an injection nozzle for internal combustion engines, a radially corrugated resilient annular member, opposed surfaces coacting with the opposite faces of said member to form a fuel spray device, means for supplying liquid fuel under pressure to the inner edge of said member, and means for adjusting the proximity of said surfaces with respect to one another to compress said member to varying degrees and thus adjust the spray characteristics of the nozzle.

3. In an injection nozzle for internal combustion engines, a thin resilient member having corrugations extending between its edges, opposed surfaces coacting with the opposite faces of said member to form a fuel spray device, means for supplying liquid fuel under pressure to one end of the corrugations of said member, and means for adjusting the proximity of said surfaces with respect to one another to compress said member to varying degrees and thus adjust the spray characteristics of the nozzle.

4. In an injection nozzle for internal combustion engines, an elongated body having a central opening extending from end to end, a rod disposed in said opening, said rod having at its inner end a head portion, a resilient corrugated annular member disposed on said rod between said head and the inner end of said body, the corrugations of said member extending outwardly from the inner edge thereof to the outer edge thereof and constituting fuel passages, means for supplying fuel under pressure to the inner edge of said member, and means at the outer end of said body for adjusting said rod longitudinally to cause said member to be compressed to varying degrees so as to adjust the fuel spray characteristics of said nozzle.

5. In an injection nozzle for internal combustion engines, an elongated body member having a central bore, a rod disposed in said bore, a valve member slidable longitudinally on said rod, a removable body section secured to the inner end of the said body member carrying a valve seat for coaction with said valve member, a fuel spray device at the inner end of the removable body section, a spring to urge the valve member against said seat, a fuel passage from the valve to the fuel spray device, a fuel supply passageway from the outer end of the body member to said valve, and a fuel bleed outlet at the outer end of the body member communicating with said bore, said rod loosely fitting said bore so as to permit the free passage of bleed liquid from the outer end of said valve member and said valve member fitting said rod with a predetermined close clearance so as to meter the amount of fuel bled from the inner end of said valve member.

6. In an injection nozzle for internal combustion engines an elongated body member, a circular spray-producing device at its inner end, a fuel supply passageway extending longitudinally of said body member, and a fuel distributing system for uniformly distributing the liquid fuel from said passageway to said fuel spray device comprising a plurality of transverse fuel channels in said body disposed in spaced relation to one another, the outermost transverse channel communicating with said fuel supply passageway, a plurality of longitudinal fuel ducts connecting said channels distributed in spaced relation around the circumference of said body and the innermost transverse channel being in communication with said fuel spray device.

7. In an injection nozzle for internal combustion engines, an elongated body member, a circular spray-producing device at its inner end, a fuel supply passageway extending longitudinally of said body member and a fuel distributing system for uniformly distributing the liquid fuel from said passageway to said fuel spray device comprising a plurality of transverse fuel channels in said body member disposed in spaced relation to one another, the outermost transverse channel communicating with said fuel supply passageway, the innermost transverse channel being disposed adjacent and in communication with said circular spray device, and a plurality of longitudinal fuel ducts interconnecting said transverse channels and distributed in spaced relation around said body member.

8. In an injection nozzle for internal combustion engines an elongated body member, a circular spray producing device at its inner end, a fuel supply passageway extending longitudinally of said body member and a fuel distributing system for uniformly distributing the liquid fuel from said passageway to said fuel spray device comprising a pair of circular fuel channels in said body member disposed in spaced relation to one another, the outer of said channels communicating with said fuel supply passageway, the inner channel being disposed adjacent and in communication with said circular spray device, and a plurality of longitudinal fuel ducts intercon-

necting said circular channels and distributed in spaced relation around said body member.

9. An injection nozzle for internal combustion engines having a spray-producing device comprising a resilient conical ring having its corrugations extending outwardly from its inner to its outer edges opposed surfaces coacting with the opposite faces of said ring to form with the corrugations thereof fuel passages, and means for adjusting said surfaces with respect to one another to compress the ring to varying degrees so as to vary the spray characteristics of said device.

10. In an injection nozzle for internal combustion engines, an elongated body having a central bore, a rod disposed in said bore, said rod having at its inner end a head portion, a resilient annular member disposed on said rod between said head and the inner end of said body, said member having corrugations extending outwardly thereof and forming with said head and the end of said body fuel passages, means for supplying fuel under pressure to the inner edge of said annular member, and means at the outer end of said body for adjusting said rod longitudinally to cause said member to be compressed to varying degrees so as to adjust the fuel spray characteristics of said nozzle.

11. In an injection nozzle for internal combustion engines, an elongated body having a central bore, a rod disposed in said bore, a valve member slidable longitudinally on said rod, a valve seat for coaction with said valve member, a fuel spray device, a spring to urge the valve member against said seat, a fuel passage from the valve to the fuel spray device, a fuel supply passageway from the outer end of the body to said valve, said valve member fitting said rod with a predetermined close clearance so as to meter the amount of fuel bled from the inner end of said valve member, and a fuel bleed outlet therefor.

12. In an injection nozzle for internal combustion engines an elongated body having a central bore, a rod disposed in said bore, said bore having at its inner end an extension adapted to project through the engine cylinder wall, a fuel spray device at the inner end of said extension, a valve seat in said body disposed outwardly from said extension, an annular fuel chamber adjacent said valve seat, a valve member longitudinally slidable on said rod having a valve portion adjacent the surface of said rod to cooperate with said valve seat, said valve member also having an annular actuating piston surface disposed outwardly from said valve, means for supplying fuel under pressure to said fuel chamber, and fuel ducts in said extension leading from said valve seat to said fuel spray device.

13. An injection nozzle for internal combustion engines comprising a thin, resilient member having corrugations extending outwardly from an inner portion thereof, opposed surfaces coacting with the opposite faces of the corrugated portions of said member to form with the corrugations thereof fuel passages, means for supplying fuel under pressure to the inner ends of the corrugations, and means for adjusting the proximity of said surfaces with respect to one another to compress the corrugations of said member to varying degrees so as to adjust the spray characteristics of the nozzle.

14. An injection nozzle for internal combustion engines having a spray producing device comprising a resilient annular member having corrugations extending between its inner and outer edges, opposed surfaces coacting with the opposite faces of said member to form with the corrugations thereof fuel passages and means for adjusting said surfaces with respect to one another to compress said member to varying degrees so as to vary the spray characteristics of said device.

15. In an injection nozzle for internal combustion engines, an elongated body having a central bore, a rod disposed in said bore, said rod having at its inner end a head portion, a conical resilient annular member disposed on said rod between said head and the inner end of said body, the end of said body being dished and the surface of said head having a conical formation to cooperate with said member to form therewith fuel passages, means for supplying fuel under pressure to the inner edge of said member and means at the outer end of said body for adjusting said rod longitudinally to cause said member to be compressed to varying degrees so as to adjust the fuel supply characteristics of said nozzle.

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