

April 29, 1958

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2,832,641

FUEL INJECTION VALVE

Original Filed May 16, 1952

3 Sheets-Sheet 1

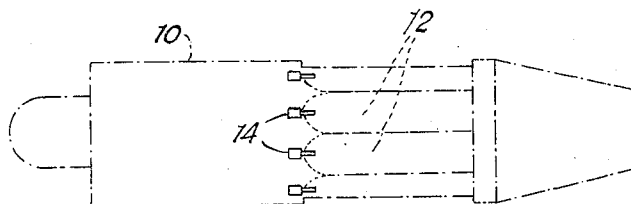


FIG. 1

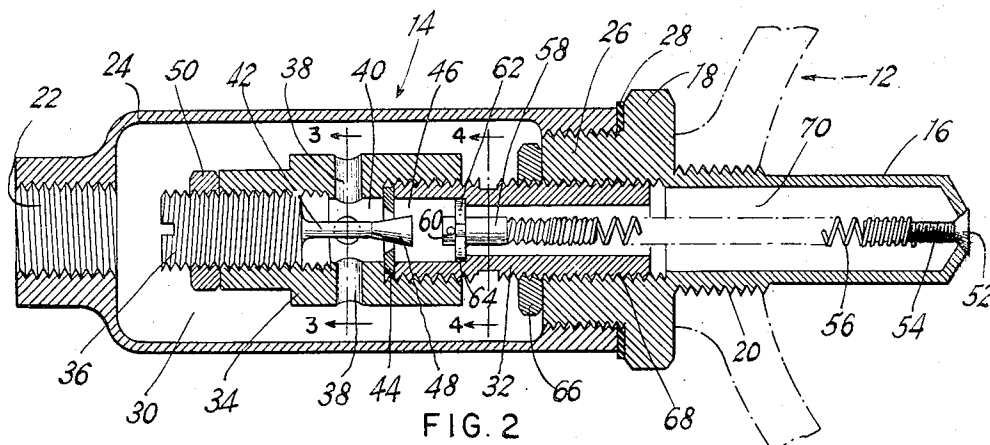


FIG. 2

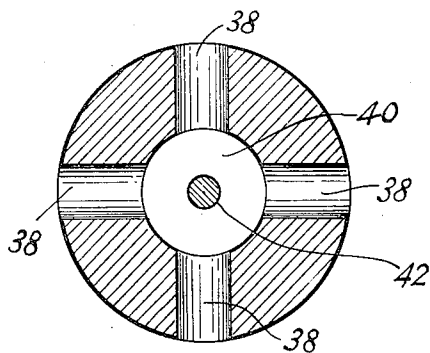


FIG. 3

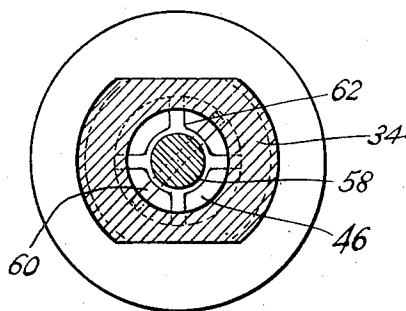


FIG. 4

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3 Sheets-Sheet 2

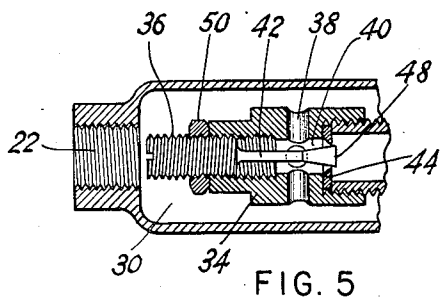


FIG. 5

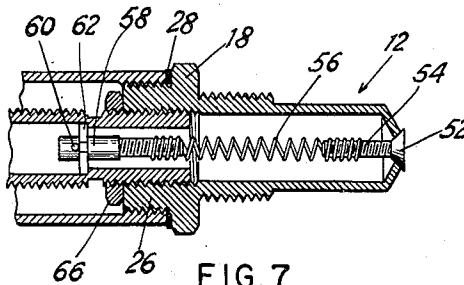


FIG. 7

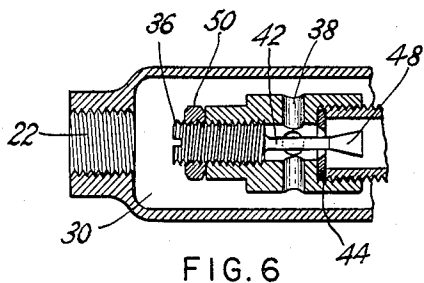


FIG. 6

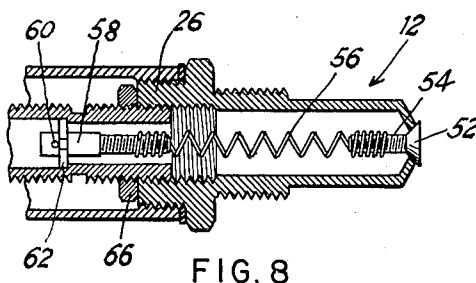


FIG. 8

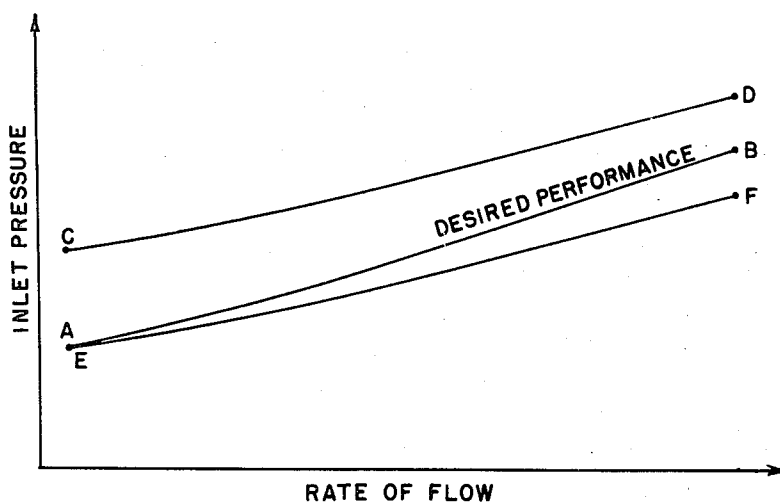


FIG. 9

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3 Sheets-Sheet 3

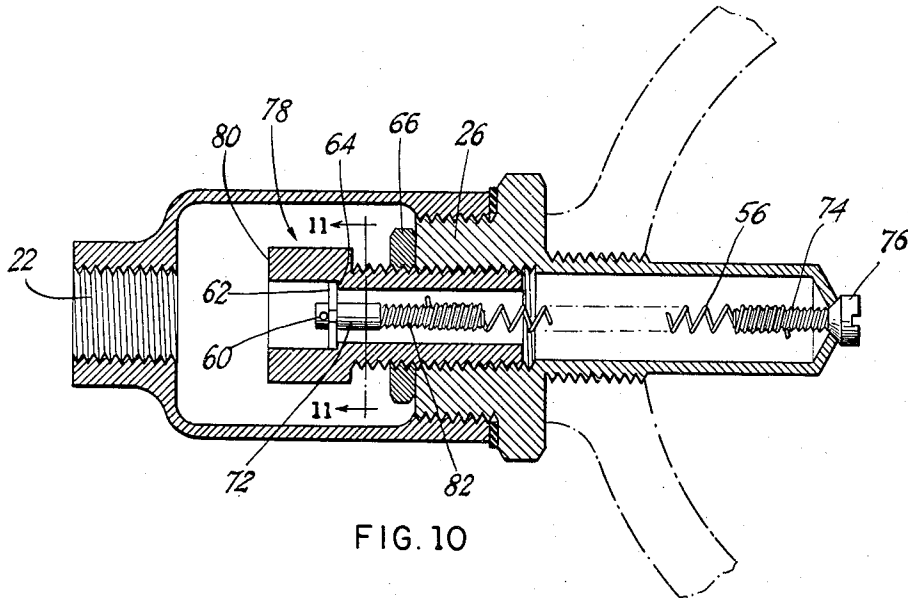


FIG. 10

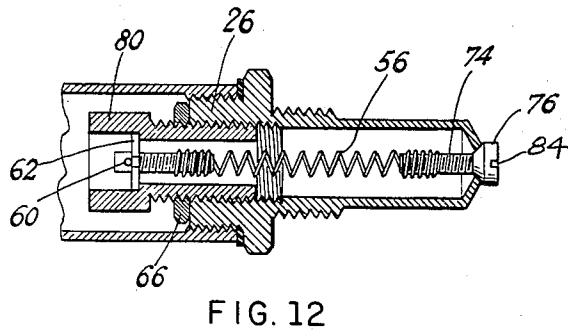


FIG. 12

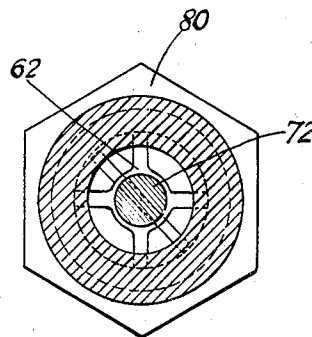


FIG. 11

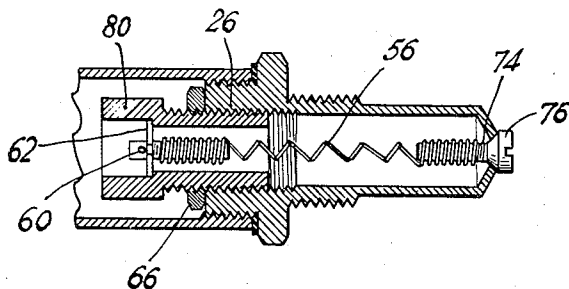


FIG. 13

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FUEL INJECTION VALVE

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Original application May 16, 1952, Serial No. 288,110.
Divided and this application January 18, 1956, Serial No. 560,036

6 Claims. (Cl. 299—107.6)

The present invention relates to fuel injection valves for internal combustion engines, and more particularly to those which are variable area orifice injection nozzles.

This application is a division of my co-pending application, Serial No. 288,110, filed May 16, 1952, for Fuel Injection Valve, now Patent No. 2,756,107, issued July 24, 1956.

The present invention contemplates the provision of such an injection nozzle which is designed and constructed so that it can be calibrated, that is used to meter the fuel as well as to atomize it.

In internal combustion engines, as, for example, particularly aircraft gas turbines, a plurality of combustion chambers may be used to drive a single turbine. Fuel for all of the combustion chambers is drawn from a common supply and the injection nozzles are relied upon to deliver an equal supply of fuel to such combustion chamber and atomize it upon delivery to the chamber.

In the past, injection nozzles having a variable exit area have been used to spray the fuel into the combustion chambers. This exit area was arranged for the most to increase with the increase in inlet fuel pressure. These variable exit area nozzles had the advantage over nozzles having a fixed or multiple exit area of providing an equivalent spray pattern at a lower maximum inlet pressure and over a wider range of fuel deliveries or flows.

Such prior variable exit area nozzles, however, had the accompanying disadvantage of difficulty in obtaining from different nozzles a consistent calibration. In other words, two or more of such heretofore variable exit area nozzles did not pass the same quantity of fuel from the common supply line in a given period of time to each combustion chamber.

In, for example, aircraft gas turbines having a plurality of combustion chambers for a single turbine, this unequal fuel delivery lead to inefficiency and possible damage and harmful effect to the engine.

The present invention therefore contemplates the provision of a variable area fuel injection nozzle which can be so adjusted to a selected relationship of flow to pressure that when a plurality of nozzles embodying my invention, are connected to a common line having a selected supply pressure, the rates of fuel flow of each nozzle will be known and will be identical with that of each other nozzle within some practical limit.

To put it another way, each nozzle may be individually adjusted to meet a condition to which it is subjected so that fuel is delivered by that nozzle at the same or other selected rate of flow as is delivered by any other nozzle in the assembly.

These, other and further advantages and objects of the present invention will be clear from the description which follows and the drawings appended thereto, in which

Fig. 1 is a schematic plan view of an internal combustion engine such as a gas turbine having a plurality of combustion chambers to each of which a variable area fuel injection nozzle embodying my invention is applied;

Fig. 2 is a longitudinal section through an injection

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nozzle embodying my invention and mounted on a combustion chamber, shown in partial section;

Fig. 3 is a section on the line 3—3 of Fig. 2;

Fig. 4 is a section on the line 4—4 of Fig. 2;

Fig. 5 is a partial view illustrating the spindle valve in closed position;

Fig. 6 is a view similar to Fig. 5 but showing the spindle valve in open position;

Fig. 7 is a partial view of Fig. 2 and showing the screw stem in one adjusted position;

Fig. 8 is a view similar to Fig. 7 and showing the screw stem in another adjusted position;

Fig. 9 is a plurality of curves each showing the relationship of the inlet pressure to the rate of fluid flow obtained with an injection nozzle;

Fig. 10 is a longitudinal section of a modified form of an injection nozzle embodying my invention and mounted on a combustion chamber, shown in partial section;

Fig. 11 is a cross section on the line 11—11 of Fig. 10;

Fig. 12 is a partial view of Fig. 10 and showing the valve in one adjusted position; and

Fig. 13 is a view similar to Fig. 12 and showing the valve in another adjusted position.

Referring now to the drawings and more particularly to Figs. 1 to 5 inclusive, an internal combustion engine 10, shown in schematic outline, is provided with a plurality of internal combustion chambers 12 to each of which is connected a fuel nozzle 14, shown in detail in Fig. 2.

A fuel nozzle 14, embodying my invention may be mounted as by threading it into a combustion chamber 12 of the internal combustion engine 10 so that the tip portion or head 18 of the nozzle 14, through which the fuel is ejected, extends into the fuel chamber the selected distance.

The upper part of the tip portion or head 16 of the nozzle 14 below the flange 18 is preferably threaded at 20 so that it may be screwed into corresponding internal threads of a combustion chamber. The entrance 22 to an injection nozzle according to my invention is internally threaded so that it may be secured to a common line running from a conventional mechanism for controlling the rate of fluid flow to the combustion chamber 12, which mechanism, since it forms no part of the present invention and is conventional, need not be illustrated. Such fluid control mechanism may be in the form of a centrifugal governor, a manually controlled throttle or any number of other well known mechanism.

The entrance 22 to my nozzle is formed in the cup-shaped cover 24 which is screwed on the threaded collar 26 extending up from the flange 18 and tightened thereon against a soft metal sealing washer 28, which prevents external leakage.

The fuel flows through the entrance 22 into the interior chamber 30 of the cover 24.

Threaded into the upper hollow tip portion or head 16, I provide the stem portion 32.

Threaded on the outside of the stem piece 32, I provide the member 34, on which is mounted the adjusting screw head 36.

The fuel flows from the chamber 30 through the openings 38 in the member 34, which are preferably spaced equally and radially thereabout, into the interior chamber 40, through which the conical spindle 42 extends axially thereof.

The orifice plate 44 is mounted at the head of the hollow stem portion or member 32. Thus axial adjustment or positioning of the spindle 42 correspondingly changes and adjusts the area of the openings in the orifice plate 44 through which the fuel flows from the interior chamber 40 in the member 34 into the communicat-

ing interior chamber 46 at the head of the stem portion or member 32.

By changing the flow area of the orifice in the plate 44 (which is dependent upon the position of the cone 48, as viewed in Fig. 2, with movement to the left of Fig. 2 decreasing the area, and movement to the right of Fig. 2 increasing the area), the pressure drop across the orifice at a constant rate of flow is correspondingly changed.

The axial position of the spindle 42 and the relative position of its cone-like head 48 to the opening in the orifice plate 44 (and thus the size of the opening through which the fuel flows) may be selectively adjusted by means of the screw head 36 and the lock nut 50.

The fluid is directed from the chamber 46 in the interior of the hollow stem member 32 into the interior of the tip portion or head 16 against the outwardly flanged valve head 52 on the pintle 54 and integral therewith.

The fluid pressure produces a force which tends to move the pintle 54 outward, that is, to the right as viewed in Fig. 2, and open the valve.

The force on the valve head 52, which tends to open the valve, is resisted by the spring 56.

In the prior art, the fluid pressure and spring force balance out at a selected point permitting the fluid to escape around the pintle 54 into the combustion chamber 12.

However, in the valve embodying my invention, the force of the spring 56 is made adjustable, one means of accomplishing which adjustment will now be described.

In one form therefore, to adjust the tension of the spring 56, one end thereof is mounted on the rod 58, which latter is supported by the pin 60 and trunnion 62 which trunnion engages a shoulder 64 in the interior of the stem portion or member 32.

The position of the stem portion or member 32 in the collar 26 of the tip portion or head 16 of my valve may be selectively adjusted by means of the lock nut 66 and the cooperating threads 68 on the stem portion 32 and the collar 26.

The tension of the spring 56 may thus be selectively changed, the pin 60 and the trunnion 62 previously twisting of the spring as the stem piece is rotated for adjustment. The other end of the spring 56 is, of course, secured to the pintle 54 in the hollow interior 70 of the tip portion or head 16.

It will now be seen that I have provided a fuel injection valve which has two adjustments, namely, an orifice area adjustment and a tension adjustment of the spring which controls the opening of the valve.

Both of these adjustments affect the fuel pressure at the valve inlet 22 which is required to maintain a given rate of fuel flow from the valve.

The effect, however, of the two adjustments are different in the operation of the valve. Changing the tension of the spring 56 causes an approximately equal increase in the pressure required at any rate of flow of the fuel, while a change in the orifice area, at the plate 44, has a disproportionately large effect on the pressure at high rates of fuel flow but has comparatively little effect on the pressure required at a low rate of fuel flow.

This difference in the effects of the two adjustments makes it possible to accurately achieve the desired performance at two different points on a pressure against flow curve.

This is seen by a consideration of the curves illustrated in Fig. 9 to which reference is now made and which represents the flow rate at different inlet pressures.

In this curve, the line AB represents the desired performance from the first group of nozzles. On a first test, a particular nozzle of this group may perform along the line CD. Reducing the spring tension by selectively threading in the stem portion or member 32, the pressure required for a given flow would be reduced and the

valve might be expected to perform along the line EF of Fig. 9.

Should the spring adjustment be made to produce the desired operation at a low rate, as illustrated, the pressure at high rates of flow may be lower than desired to obtain the required performance.

The orifice area may then be adjusted by means of the conical spindle 42 until the nozzle performance is that desired at high rates and thereby produce an operating curve such as that shown on the line AB of Fig. 9.

Thus, proper adjustment of both the orifice area and the spring tension will be seen to produce a rapid convergence to the desired operation. Thus, injection valves embodying my invention produce proper and desired performance at both high and low inlet pressures.

A nozzle embodying my invention may thus be used to meter the equal distribution of fuel among several combustion chambers as well as provide the sprayed or atomized injection of the fuel thereinto and at the same time is capable of adjustment to provide a pre-selected relationship between fuel inlet pressure and the rate of fuel flow.

The same results and purposes may be accomplished by other embodiments of my invention, one of which is illustrated in Fig. 10, to which reference will now be made. Like reference characters will be used to designate like parts.

It has been established in engineering practice that the rate at which the force of a spring increases with deflection, which is referred to as the spring's "rate," is inversely proportional to the number of active coils in the spring.

It will be apparent that any coil which is firmly gripped by a rigid member such as the rod 72 or the pintle 74 on which the valve head 76 is formed, is not active.

Therefore, in Fig. 10, I have shown a means for actively engaging a greater or lesser number of spring coils.

The inner end of the stem portion 78 is threaded into the collar 26 and held there by the lock nut 66. The upper end 80 of the stem portion 78 is recessed to receive the trunnion 62, which is held against the shoulder 64. The rod 72 is held to the trunnion by means of the pin 60, and its threaded end 82 receives one end of the spring 56. Pin 60 acts against force of spring 56 and pin 60 rests against trunnion 62. This arrangement allows rod 72 to rotate.

The pintle 74 is threaded and receives the other end of the spring 56, the valve head 76 being inwardly recessed at 84 to receive an adjusting screw driver.

Thus, different coils of the spring may be engaged by the rod 72 at the upper end of the spring, that is, to the left of Fig. 10, and different coils by the pintle 74, that is, to the right of Fig. 10. Thus, the spring rate may be selectively adjusted by rendering inactive different numbers of coils at each end of the spring 56.

In the type of assembly illustrated in Fig. 10, the difference between the pressures required for low and for high fuel flows is determined solely by the change in the force exerted by the spring as it extends to accommodate the higher flows. Hence, the effect of changing the spring rate is the same as the effect of changing the orifice area in the unit illustrated in Fig. 2 and the same adjustment may be achieved. Adjustment of the spring tension by means of 80 remains as in Fig. 2.

It will now be apparent that I have provided a fuel injection nozzle which can be adjusted to have the same performance as that of any other valve of this type, and which valve performs as desired at both high and low inlet pressures to thereby equally distribute the fuel among several combustion chambers.

While I have shown and described certain specific examples of my invention, it will be understood that such examples are illustrative only and are not given as limitations, since other modifications within the spirit and

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scope of the invention will be apparent to those skilled in the art.

Hence, I do not intend to limit myself thereto but intend to claim my invention as broadly as may be permitted by the state of the prior art and the terms of the appended claims.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. In a fuel injection valve, a hollow body having an entrance thereto, a tip portion extending therefrom and having a hollow interior communicating with the interior of the hollow body, a threaded member having an interior chamber arranged in the hollow body and having a plurality of openings radially disposed about the member and communicating with the interior of the hollow body and the interior chamber, an orifice plate intermediate the said interior chamber, a threaded adjusting means in the threaded member, a spindle mounted on the said adjusting means and having a cone-shaped head extending through the orifice plate to enlarge or decrease the orifice in the plate upon corresponding adjustment of the threaded adjusting means, said tip portion having an opening communicating with the hollow interior of the tip portion, a spring controlled pintle, a valve head on the pintle for opening and closing the opening in the tip portion and means for adjusting the spring controlling the pintle.

2. In a fuel injection valve, a hollow body having an inlet thereto, a tip portion secured to said hollow body and extending therefrom and having a hollow interior and being formed with a discharge opening, a member screwed to said tip portion and projecting into said hollow body and being formed with passages communicating with the interior of the hollow body and with the interior of said tip portion, means forming a valve passage within said last member, adjustable means to vary the effective area of said valve passage, valve means closing said discharge opening in said tip portion, spring means connected to said last mentioned valve means, means to connect said spring means to said member whereby upon screwing said member relative to said tip portion the tension of said spring means will be varied.

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3. The combination of claim 2, said means for varying the effective area of said valve passage comprising a conical pin within said valve passage and means to move said conical pin axially relative to said valve passage.

4. A fuel injection valve comprising a hollow body having an inlet opening at one end, a tip portion screwed to the opposite end of said hollow body and extending therefrom, said tip portion having a through passage being formed with a discharge opening at its outer end, a sleeve screwed within said tip portion and projecting into said hollow body and being formed with an internal shoulder, a pintle having a head engaging said discharge opening and projecting into said tip portion, a trunnion engaging said internal shoulder, a coil tension spring interconnecting said pintle and trunnion, a second sleeve connected to the first sleeve and located wholly within said hollow body, a valve plate interposed between said sleeves and formed with a valve opening and a screw screwed within said second sleeve and having a pin extending therefrom and formed with a conical portion disposed within the valve opening of said plate and said second sleeve being formed with a through passage located between said valve plate and screw to permit flow of fuel from the hollow body into said second sleeve and to said valve opening in said plate.

5. The combination of claim 4 in which said coiled tension spring has threaded engagement with said pintle and trunnion.

6. The combination of claim 5 in combination with lock nut means to lock the first sleeve to the tip portion and lock nut means to lock said screw to said second sleeve.

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