July 24, 1956 E. J. KORDA 2,756,107

FUEL INJECTION VALVE

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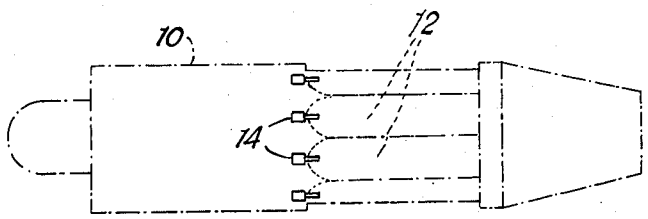


FIG. 1

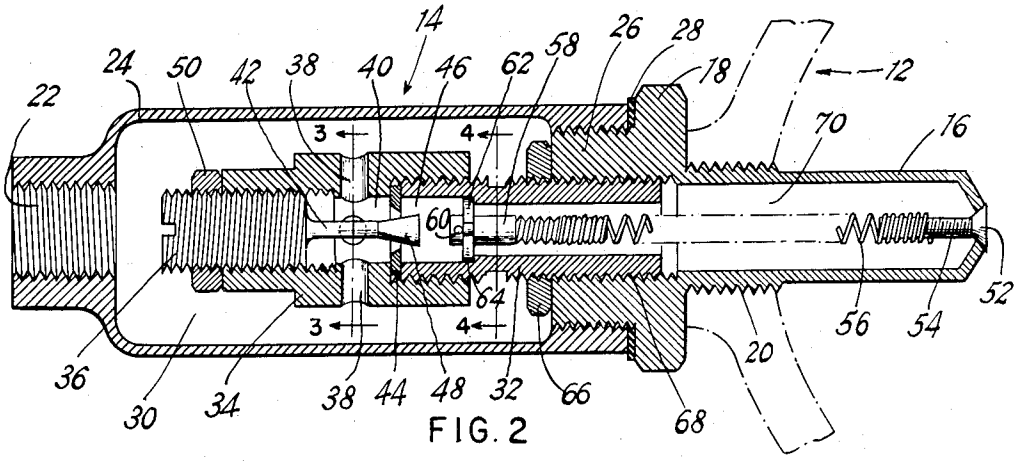


FIG. 2

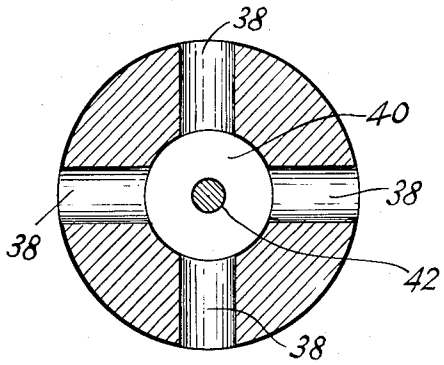


FIG. 3

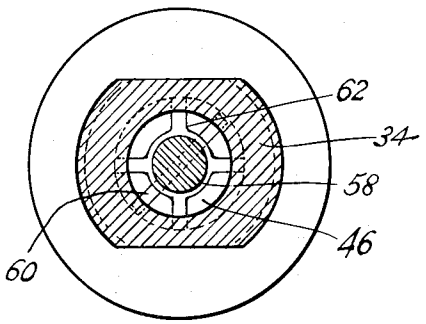


FIG. 4

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FUEL INJECTION VALVE

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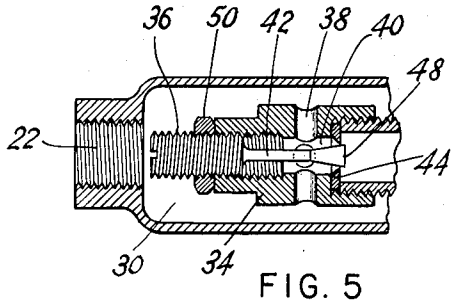


FIG. 5

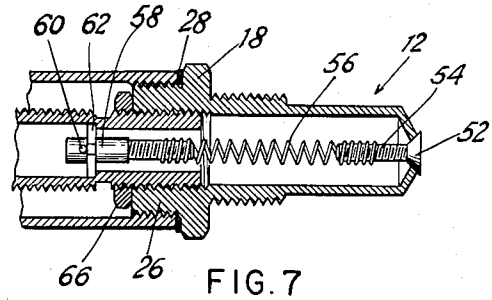


FIG. 7

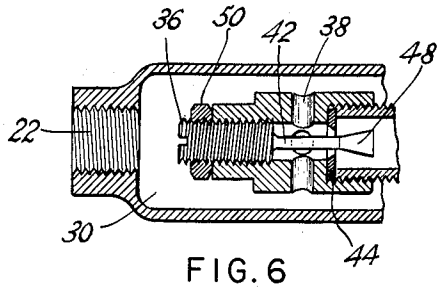


FIG. 6

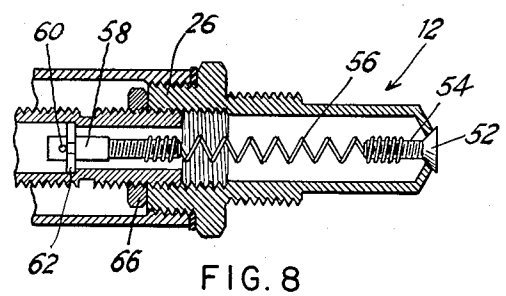


FIG. 8

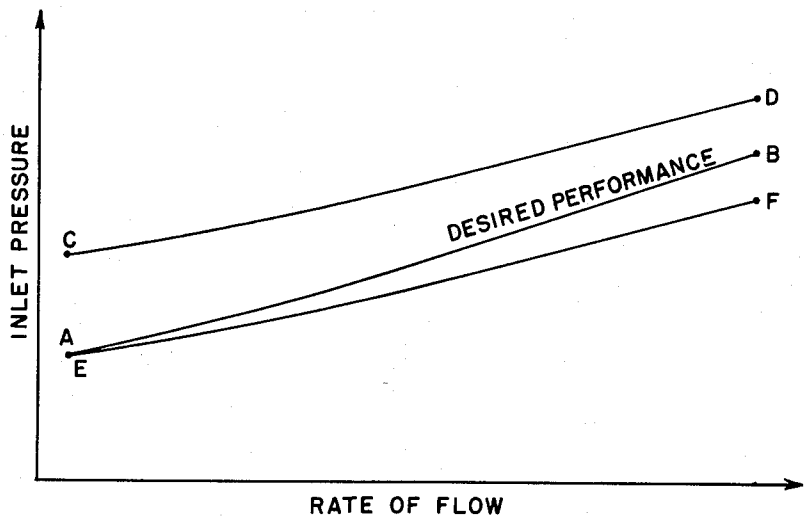


FIG. 9

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FUEL INJECTION VALVE

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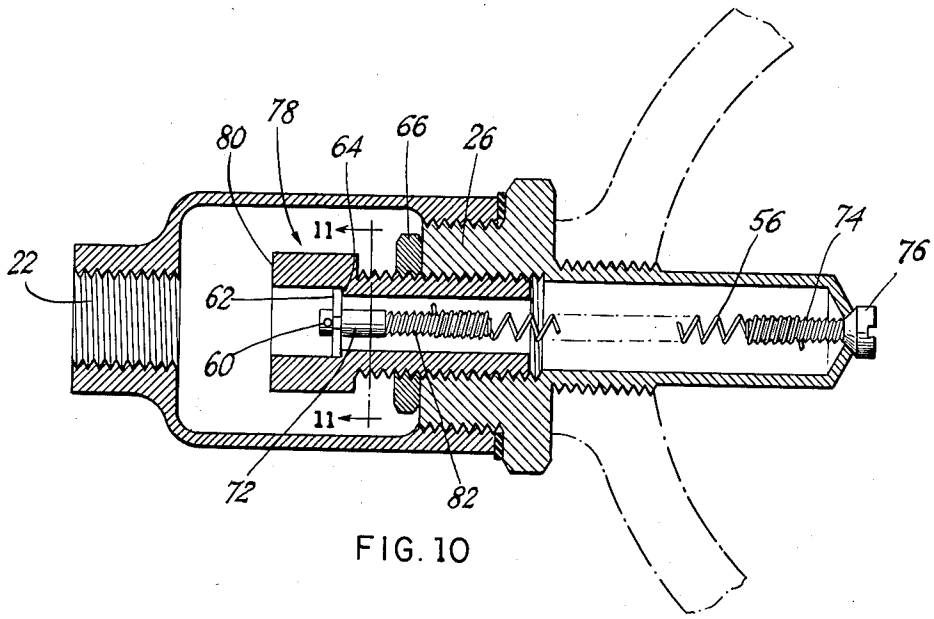


FIG. 10

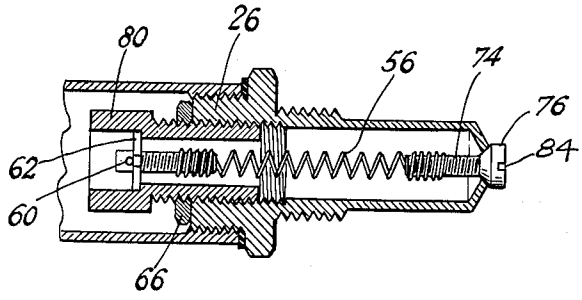


FIG. 12

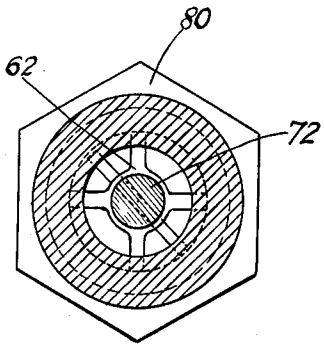


FIG. 11

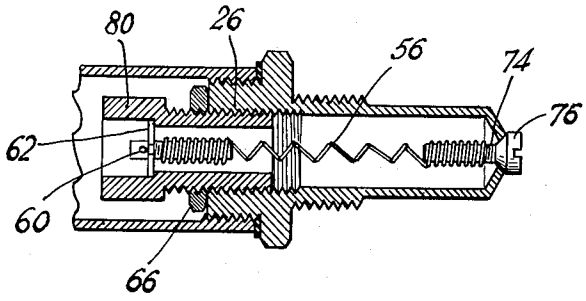


FIG. 13

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FUEL INJECTION VALVE

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Application May 16, 1952, Serial No. 288,110

3 Claims. (Cl. 299—133)

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

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 each 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 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. 1.

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.

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 incl., 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 to 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 **16** 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 chambers **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 mechanisms.

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**, we 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 communicating 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 in-

creasing 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** preventing 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 flow 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 and 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 sepecific 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 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.

I claim:

1. In a fuel injection valve, a body having a hollow interior, an entrance to the interior of the body, a hollow

tip portion threaded to the body, a hollow stem threaded to the tip portion and connecting the hollow interior of the body to the hollow interior of the tip portion, a valve head for opening and closing the tip portion, a threaded element extending from the valve head into the interior of the tip portion, a trunnion fixedly held in the stem, a threaded rod extending from the trunnion into the stem and a coiled spring threaded at one end on the rod and at other end on the threaded element, said valve opened by the pressure of the fuel discharged from the valve against the valve head in opposition to the tension of the spring, said rod and said element being adjustably threaded into the coil spring to engage a se-selected coil at each end of the spring to thereby adjust the spring rate whereby the flow of fuel from the valve is determined by the force exerted by the spring.

2. A fuel injection valve comprising a tubular nozzle spray tip formed with a valve opening at its outer end providing a valve seat, a valve head at said seat to close said opening, a tubular member screwed to the rear end of the nozzle tip, said tubular member being formed with an internal shoulder, a spider contacting said shoulder, said spider and said valve head being formed with stems projecting toward each other, a coil tension spring interconnecting said stems, one of said stems comprising a screw adapted to threadedly engage one end of said spring so that rotation of the stem will vary the number of active coils in said spring.

3. A fuel injection valve comprising a tubular nozzle spray tip formed with a valve opening at its outer end providing a valve seat, a valve head at said seat to close said opening, a tubular member screwed to the rear end of the nozzle tip, said tubular member being formed with an internal shoulder, a spider contacting said shoulder, said spider and said valve head being formed with stems projecting toward each other, a coil tension spring interconnecting said stems, one of said stems comprising a screw adapted to threadedly engage one end of said spring so that rotation of the stem will vary the number of active coils in said spring, a hollow body attached to the rear end of the nozzle tip and enclosing the rear end of said tubular member, and said body being formed with an inlet opening.

References Cited in the file of this patent

UNITED STATES PATENTS

2,041,050	Cunningham	May 19, 1936
2,452,283	Ball	Oct. 26, 1948
2,555,803	Mashinter	June 5, 1951

FOREIGN PATENTS

504,875	Great Britain	May 2, 1939
909,177	France	Dec. 10, 1945