United States Patent [19]

Bitonti

[11] **3,762,378**

[45] **Oct. 2, 1973**

[54] **FUEL INJECTION MEANS AND PROCESS FOR MAKING SAME**

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[22] Filed: **Nov. 8, 1971**

[21] Appl. No.: **196,624**

[52] **U.S. Cl.** ..... **123/32 H,** 123/34 A, 123/122 E

[51] **Int. Cl.** **F02b 3/00,** F02m 31/00

[58] **Field of Search** ..... 123/32 H, 34 A

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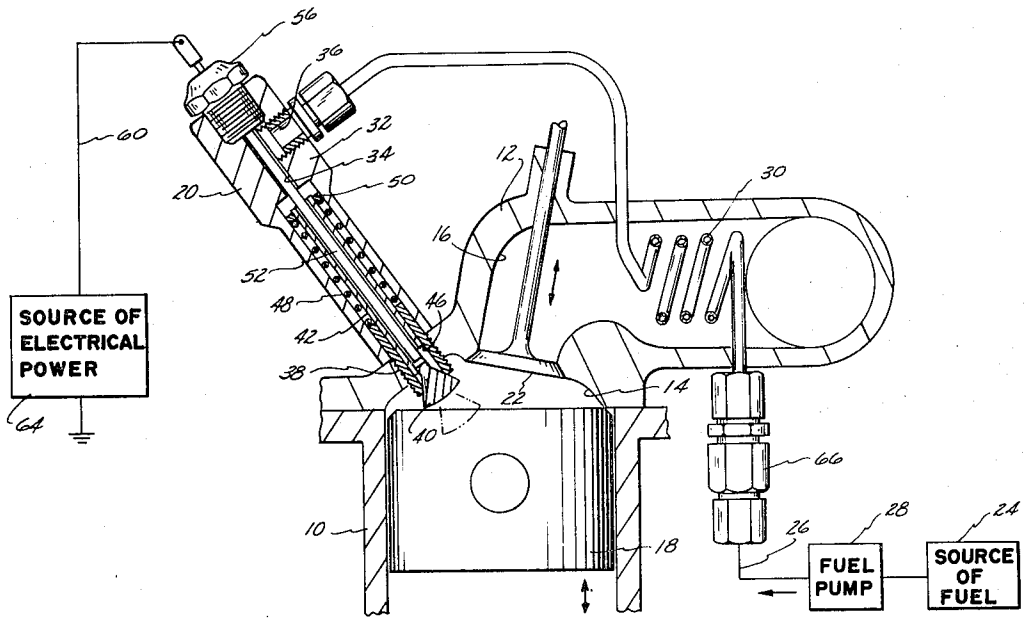
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Assistant Examiner—Ronald B. Cox
Attorney—Charles W. Chandler

[57] **ABSTRACT**

In an internal combustion engine, a fuel injector having a valve with an elongated hollow stem which functions as a conduit for fuel being delivered to the valve opening. A heater probe is telescopically disposed in the stem to preheat the fuel. The valve is biased by a calibrated spring arrangement that is suited for automatic assembly.

8 Claims, 4 Drawing Figures



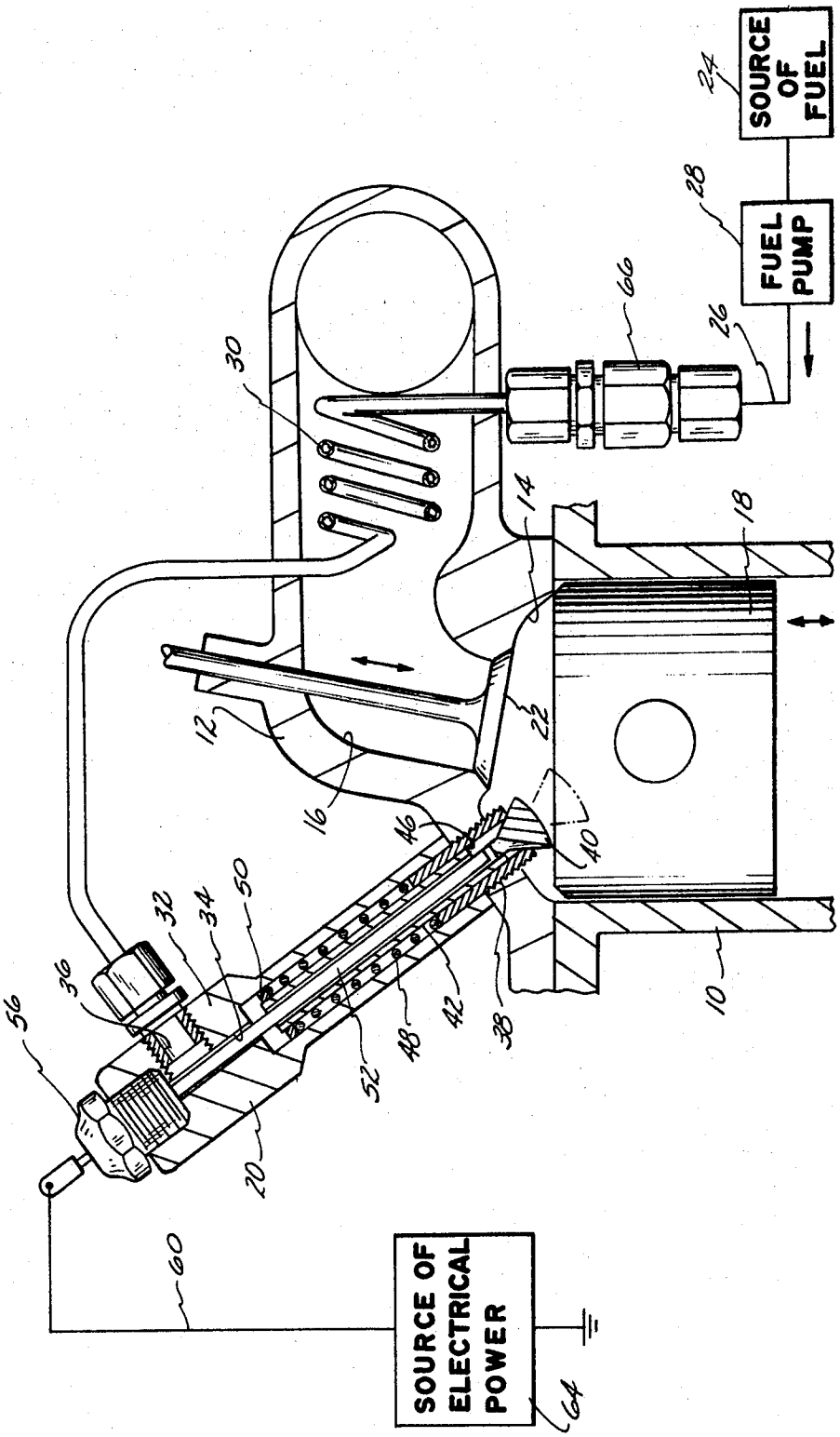

SOURCE OF FUEL
FUEL PUMP
SOURCE OF ELECTRICAL POWER
24
28
26
66
30
14
18
12
22
16
46
40
32
34
50
36
56
52
48
42
38
10
20
60
64

FIG - 1

FIG-2

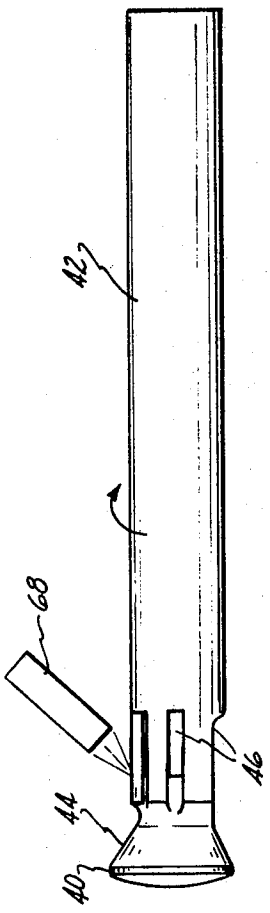
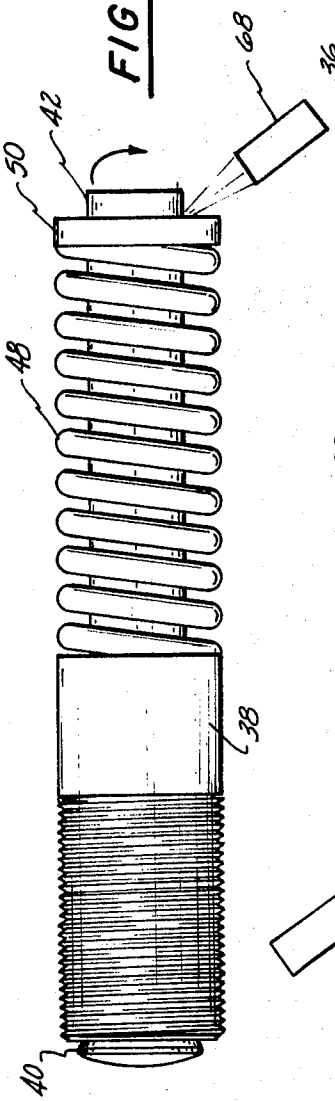


FIG-3



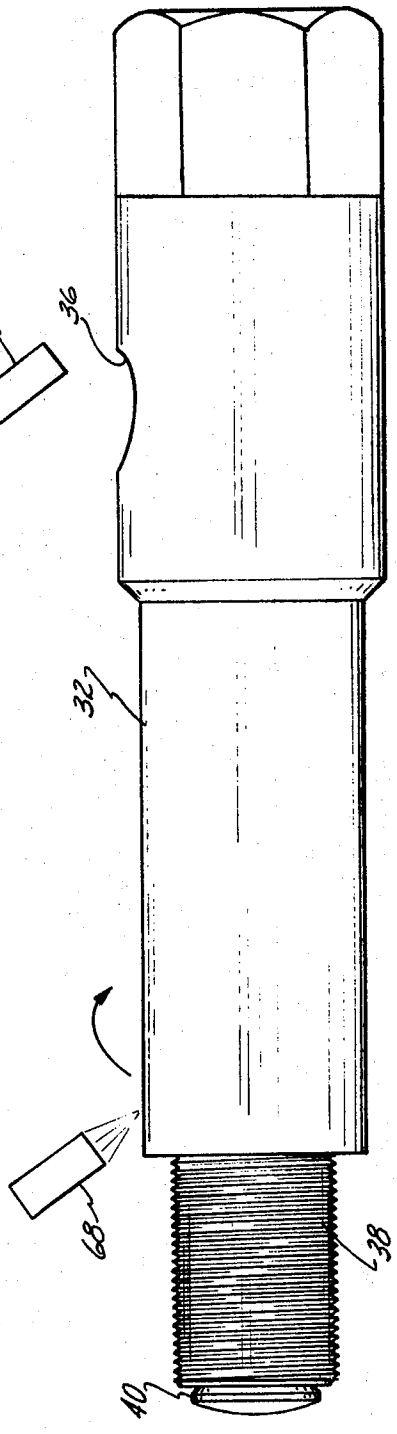


FIG-4

FUEL INJECTION MEANS AND PROCESS FOR MAKING SAME

BACKGROUND OF THE INVENTION

This invention is related to fuel injectors for internal combustion engines and more particularly to an injector assembly having a valve for discharging fuel that is heated as it passes through the valve stem, and to a process for mounting a spring assembly on such a valve stem.

Some internal combustion engines employ means for injecting metered amounts of fuel into a combustion chamber where the fuel is ignited by suitable means. The injector valve is opened in response to fuel pressure and closed by a spring. The spring bias is usually calibrated and mounted in position by a time-consuming hand assembly process.

In order to ignite properly during cold weather, the fuel used by fuel injectors must be preheated. Although electrical heaters have been disclosed in the art for preheating the fuel until the engine reaches its operating temperature, an injector that allows the fuel to be in contact with such a heater in a position adjacent the discharge opening into the combustion chamber has not been commercially available.

SUMMARY OF THE INVENTION

The preferred embodiment of the invention is described as a component of a hypergolic injection system in which the pressure and temperature of the fuel in the injector is such that it spontaneously ignites upon being delivered into contact with oxygen in the air in the combustion chamber. The injector has a body mounted in the engine head with an outlet opening adjacent the engine combustion chamber. An electrical heater is mounted in the body with an elongated probe disposed adjacent the outlet opening. A valve having a hollow stem is telescopically mounted on the heating probe to provide a passage having an annular cross-section in the stem for fuel passing to the outlet opening.

An inlet opening in the injector body receives fuel which is passed into the valve stem so as to be heated until the valve is opened in response to fuel pressure. As the valve is opened, the fuel passes from the valve stem and through the outlet opening.

The injector is assembled by mounting an annular retainer, that also functions as a valve seat, on the valve stem. A spring is then mounted on the stem and then a second retainer. The spring is compressed by the second retainer according to the fuel pressure that is to open the valve. The second retainer is then welded to the stem by an electron beam to form a calibrated valve assembly. The valve assembly is disposed in the body and the first retainer welded by an electron beam to the injector body.

The preferred injector is composed of a relatively few parts that can be assembled in an automated assembly line to provide injectors having reasonably uniform operating characteristics. The position of the heater ensures an efficient transfer of heat to the fuel as the injector valve is being opened and closed. Still further objects and advantages will become readily apparent to those skilled in the art of the invention upon reference to the following detailed description.

DESCRIPTION OF THE DRAWINGS

The description refers to the accompanying drawings in which like reference characters refer to like parts throughout the several views, and in which:

FIG. 1 is a fragmentary, sectional view of an internal combustion engine having a fuel injector illustrating the preferred embodiment of my invention;

FIG. 2 is an enlarged view of the injector valve showing the manner in which the valve head is welded to the stem;

FIG. 3 is a view showing the spring being mounted on the valve; and

FIG. 4 is a view showing the manner in which the valve assembly is mounted on the injector body.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, an engine housing **10** is illustrated in FIG. **1**. A head **12** is mounted on housing **10** to provide a combustion chamber **14** and an exhaust passage **16** for the removal of combustion products from chamber **14**. A piston **18** is disposed in housing **10** to function as a power member in the manner well known to those skilled in the art.

Fuel injector **20** is mounted on head **12** for delivering metered amounts of fuel to combustion chamber **14**. An exhaust valve **22** is mounted adjacent the fuel injector for opening and closing communication between the combustion chamber and exhaust passage **16**.

For illustrative purposes, the preferred fuel injector provides fuel for chamber **14** which ignites as a result of being heated above its ignition temperature and then being introduced into an environment having a lower pressure than in the injector and sufficient oxygen to support combustion. This fuel delivery method is known as hypergolic injection. The object is to ignite the fuel before it reaches the combustion chamber walls to eliminate the quenching effect that is a cause of air pollution by conventional engines. However, the preferred injector can be employed in other types of internal combustion engines.

The fuel system comprises deliverying the fuel from a source **24** through conduit means **26** by means of pump **28**. Conduit means **26** includes a spiral coil **30** disposed in exhaust passage **16** to heat the fuel before it is received by injector **20**.

Injector **20** has an elongated hollow body **32** with a longitudinal bore **34** for receiving fuel through an inlet **36**. A hollow elongated retainer **38** is mounted at the lower enlarged end of bore **34**, and has a threaded section mounted in head **12**. A valve having a head **40** mounted on the end of an elongated hollow stem **42**, is slideably mounted in retainer **38**. Valve head **40** is movable between a closed position illustrated in solid lines in FIG. **1**, and an open position illustrated in phantom. In its closed position, the valve head is engaged with a tapered seat formed on the end of retainer **38**. In its open position, valve head **40** has a tapered neck **44** to provide a cone-shaped charge of fuel into the combustion chamber. The fuel passes from inlet **36** to stem **42** and then passes the length of the stem to a series of openings **46** located adjacent head **40**.

A spring **48** is mounted on stem **42**, one end being engaged with retainer **38** and its other end engaged with a second retainer **50** mounted on the end of the stem. Spring **48** is pre-loaded when the fuel injector is being

assembled to bias valve head **40** toward its closed position and to open in response to a predetermined fuel pressure applied on the tapered neck of the valve head.

An electrically energized heater having an elongated probe **52** is disposed in body **32.** The lower end of probe **52** is disposed in valve stem **42** adjacent openings **46.** The diameter of heater probe **52** is less than the bore of valve stem **42** to form a fuel passage having an annular cross-section. As the fuel passes through the stem, it is in contact with the heater probe until being discharged from the stem in response to opening of valve head **40.** Thus, the heater probe provides a relatively large surface area in contact with the fuel and also functions as a sheath to protect an internally housed heating element (not shown) from direct contact with the fuel.

A plug **56** is engaged with the outer end of heater probe **52** to support it in body **32.** A lead **60** connects heating probe **52** to a source of electrical power **64.** Heater probe **52** is energized to heat the fuel when the engine is being started and under those conditions when the heat transferred to the fuel passing through coil **30** is insufficient to heat the fuel to its ignition temperature at the injector outlet.

A retractor valve **66** is located in conduit means **26** adjacent coil **30** to maintain the fuel pressure in injector **20** above the critical pressure of the fuel but below the opening pressure of valve head **40** between pressure impulses.

Preferably injector **20** is assembled as follows: Referring to FIG. **2,** valve stem **42** is formed of metal tubing. Head **40** is joined to the end of stem **42** by electron beam welder **68.** The welded seam is ground smooth, and then openings **46** formed by any suitable means. Advantages of using the electron beam welder is that the weld joint can be formed without weld metal and with little heat distortion.

Referring to FIG. **3,** retainer **38,** spring **48** and retainer **50** are mounted on stem **42.** With valve head **40** seated in its closed position in the end of retainer **38,** retainer **50** is moved toward retainer **38** until spring **48** is preloaded according to the fluid force that is to open valve **40.** Retainer **50** is then joined to stem **42** by electron beam welder **68** to complete the calibrated valve assembly.

Then the valve assembly is disposed in body **32** as illustrated in FIG. **4.** Retainer **38** is connected to the end of body **32** by electron beam welder **68** to complete the assembly.

The preferred fuel injector is threadably mounted in engine head **12** to permit removal for cleaning or maintenance in the manner of a spark plug. Similarly, heating probe **52** is removable from its position in body **32** without the necessity of dismantling the remainder of the fuel injector.

Having described my invention, I claim:

1. In an internal combustion engine, the combination comprising:

an engine housing having a combustion chamber therein;

a power member movably disposed in the combustion chamber;

fuel injection means for delivering fuel to said chamber for combustion including:

a body mounted on said engine housing, said body having an inlet for receiving fuel, and an outlet for the passage of fuel from the body toward the combustion chamber;

a valve member mounted in the body adjacent said outlet so as to be movable toward an open position to allow fuel passage through the outlet;

a bias member mounted in the body and connected to the valve member to urge it toward a closed position to block fuel passage through the outlet;

an elongated valve stem connected to the valve member, and having an inlet for receiving fuel, and an outlet adjacent the valve member for passing fuel; and

electrically operated heating means mounted on the body, including an elongated heating probe disposed in the inlet of the valve stem, the heating probe having a length such that it is disposed adjacent the outlet of the valve stem at such times as the valve member is disposed in said closed position.

2. A combination as defined in claim **1,** including a pump connected to the inlet of said body for delivering fuel at a pressure sufficient to move the valve member toward said open position.

3. A combination as defined in claim **1,** in which the valve member has a frusto-conical surface engageable with a seat having a complementary shape.

4. A combination as defined in claim **1,** in which the body has an annular retainer with a bore slideably receiving the valve stem, the retainer being shaped to seat the valve member in said closed position.

5. A combination as defined in claim **4,** including a bias member engaged with the retainer and a second retainer mounted on the valve stem so as to be movable therewith, the second retainer being engaged with the bias member and so spaced with respect to the first mentioned retainer whereby the bias member prevents motion of the valve member from said closed position unless fuel of a predetermined pressure urges the valve member toward said open position.

6. A combination as defined in claim **1,** in which the valve stem is moved with respect to the heating probe as the valve member is moved from its open toward its closed positions.

7. A combination as defined in claim **1,** including a source of fuel, heat exchanger means, and a fuel pump for delivering fuel from said source through the heat exchanger means to the inlet of said body.

8. A combination as defined in claim **7,** in which the heat exchanger means includes a head having an exhaust passage for passing combustion products from the combustion chamber, and a conduit for receiving fuel from the fuel pump, the conduit forming a coil disposed in the path of combustion products being passed through the exhaust passage.

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