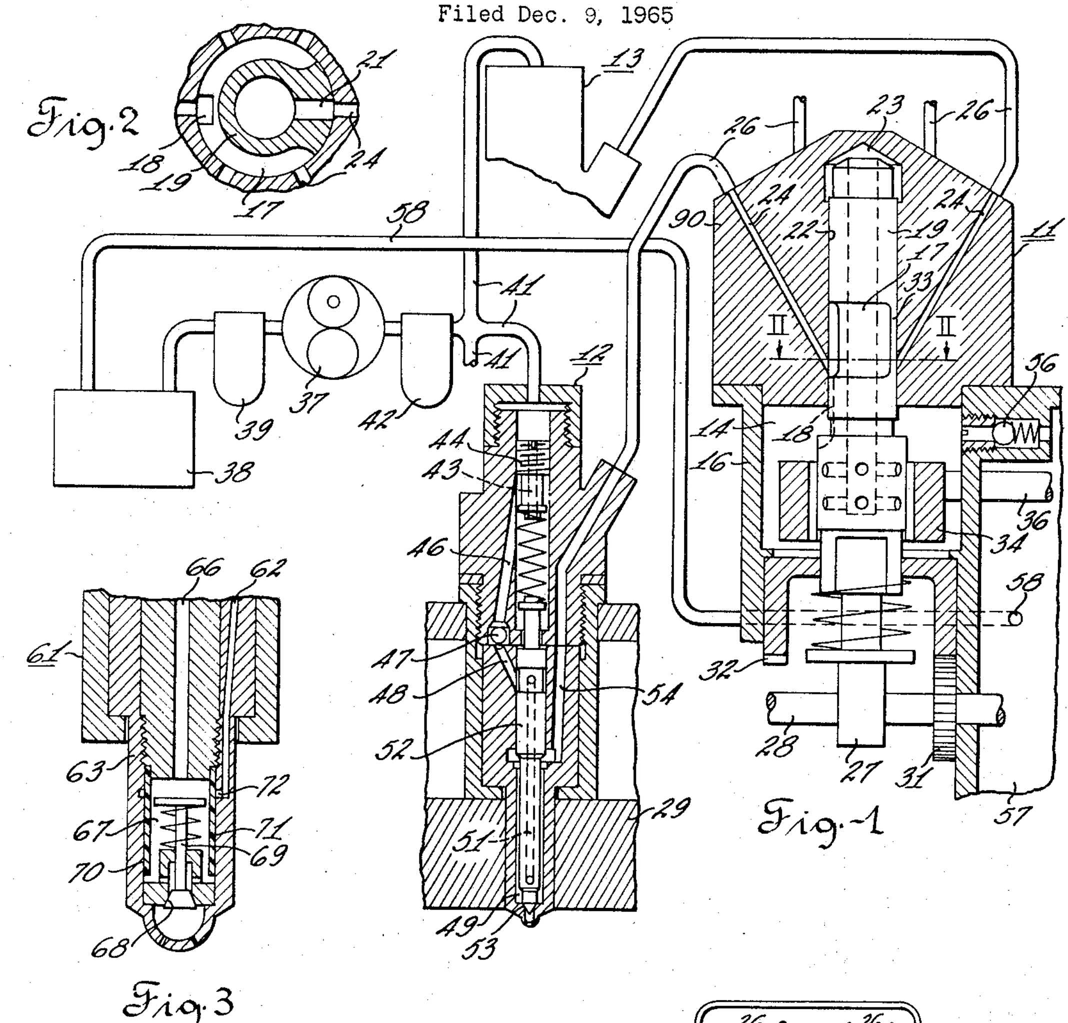
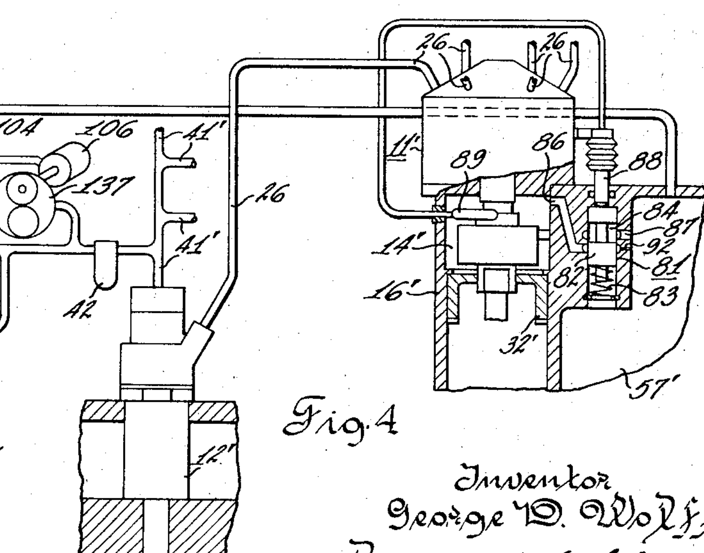
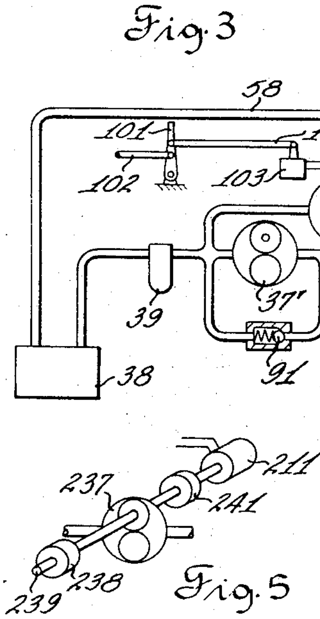
Nov. 14, 1967 G. D. WOLFF 3,352,245

FUEL INJECTION SYSTEM

Filed Dec. 9, 1965







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3,352,245

Patented Nov. 14, 1967

3,352,245
FUEL INJECTION SYSTEM

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Filed Dec. 9, 1965, Ser. No. 521,237
15 Claims. (Cl. 103—2)

This invention relates to means for regulating the temperature of fuel injectors of internal combustion engines employing solid injection of fuel.

Heretofore the seat areas of injection nozzles have lost hardness due to high engine temperatures developed at the injectors. This problm becomes increasingly serious in engines with high thermal loads such as supercharged engines. Also, it has been shown that during idle operation of an engine, acid corrosion of the injector parts may occur when these parts are below about 40 degrees centigrade. During combustion sulphur trioxide (SO_3) is formed and condenses on the cooler steel parts of the injector forming sulphuric acid which corrodes the surfaces of the injector parts.

It is an object of this invention to provide a fuel injection system employing a distributor type fuel injection pump and pressure operated injection nozzles wherein the nozzles are cooled by fuel flow from a supply pump to the injection pump.

It is a further object of this invention to provide a fuel injection system as outlined in previous object wherein thermostatic or temperature responsive means are employed to substantially prevent cooling fuel flow until the injector temperature is above a predetermined minimum.

It is a further object of this invention to provide injector cooling in a fuel injection system having a precharged fuel injection pump, that is an injection pump wherein the injector lines are precharged at an intermediate supply pressure during noninjection intervals.

It is a further object of this invention to provide a fuel injection system wherein the nozzles are not only cooled by fuel flow therethrough during noninjection intervals but also for a predetermined time following engine shutdown.

These and other objects and advantages will be apparent when the following description is read in conjunction with the drawings, in which:

FIG. 1 is a partially schematic showing of one embodiment of my invention;

FIG. 2 is a section view taken along line II—II in FIG. 1;

FIG. 3 is a section view of an outward opening nozzle with diaphragm check valve means;

FIG. 4 is a partially schematic showing of a second embodiment of my invention; and

FIGURE 5 is a schematic showing of an alternate embodiment of the present invention wherein an overriding clutch drive means is employed.

Referring to FIGS. 1 and 2 the precharged fuel injection pump **11** is similar to the injection pump shown in my copending U.S. patent application Ser. No. 405,189, filed Oct. 20, 1964, Precharged Fuel Injection Pump, now abandoned. The pump **11** does not have a so-called delivery valve and the reflected pressure waves from the nozzles **12, 13** are absorbed in the supply chamber **14** of the pump housing **16** since the nozzles are connected to the supply chamber by recess **17** and groove **18** in the plunger **19** during the time interval they are not being supplied injection pressure fuel via delivery port **21**. The head of the pump housing **16** has a bore **22** in which plunger **19** reciprocates to pressurize fuel in pressure chamber **23** at the closed end of the bore and a plurality of delivery passages **24** adapted at the outer terminus for connection to injection conduits or lines **26**. The pump plunger is reciprocated by a cam **27** on a power take-off shaft **28** of a compression ignition engine **29** and is rotated by gears **31, 32**. As the plunger is rotated, the distributor portion **33** of the plunger **19** cyclically connects the delivery passages to the delivery port and the supply chamber. A control sleeve **34** is provided to control the effective length of the pumping stroke and the timing of the fuel injection through axial shifting and rotating the sleeve by a suitable control member **36**.

During operation, the supply pump **37** draws fuel from the source (reservoir) **38** by way of filter **39** and delivers it through conduit means, including branch conduits **41**, by way of filter **42** to injectors **12** and **13**. Fuel passes downwardly through a central opening **43** in adjustable spring seat **44** and hence through passage **46** past a check valve **47**, through passage **48** to cavity **49** by way of passage **51** in the differential pressure valve **52**. It will be noted that the lower terminus of the passage **51** is adjacent the vale seat **53** and thus the flow of fuel through the cavity **49** will effectively cool the nozzle parts subjected to the highest temperatures. Fuel supplied the cavity **49** by supply pump **37** passes to the supply chamber **14** of the injection pump **11** via passage **54** in the nozzle **12**, line **26** connected thereto, passage **24** in the injection pump **11**, recess **17** and groove **18** in the plunger.

A pressure regulating valve **56** is provided in the pump housing **16** which opens at about 50 p.s.i. Fuel passing through valve **56** flows into the governor housing chamber **57** from whence it passes to the source **38** through return conduit **58**.

Since the precharging recess **17** connects the delivery passages **24** to the supply chamber during the time they are not used for injection, the associated nozzles will be cooled by flow of fuel from supply pump **37**. When pressurized fuel is delivered by the injection pump **11** to a nozzle, such as delivery to nozzle **13** as shown in FIGS. 1 and 2, the check valve therein will close and the inwardly opening valve thereof will rise against its spring and fuel will be injected into the associated engine cylinder.

In FIG. 3 I show a novel outwardly opening nozzle **61** which may be substituted for inwardly opening nozzles **12, 13**. The supply line **41** of FIG. 1 would be connected to the upper end of passage **62** in the body **63** of nozzle **61** and the delivery line **26** of FIG. 1 would be connected to passage **66** in body **63**. The inner end of passage **62** terminates annular groove **72** at the cavity **67** in nozzle body **63**. A resilient cylindrical diaphragm **71** covers the groove **72** and acts as a check valve during operation of the fuel injection system. The diaphragm deflects inwardly to permit flow of fuel from the supply pump downwardly between the wall **70** of cavity **67** and the outer cylindrical surface of diaphragm **71** to cool valve element **69** and seat **68**. When pressure wave of fuel delivered by the injection pump to passage **66** arrives at cavity **67** the diaphragm **71** is pressed against the wall **70** to close the recess **72**. The radical clearance between the valve **69** and the wall **70**, needed for flow of fuel and proper operation during injection, is utilized during cooling by the inwardly expanded diaphragm **71**. This minimizes the diameter of the nozzle.

In FIG. 4 a thermostatic or temperature responsive valve **81** is installed in the pump housing **16'**. The spool **82** of valve **81** is shifted downwardly against the action of spring **83** to permit normal fuel flow and pressure relief, from supply chamber **14'** to governor chamber **57'** by way of annular recess **84** in spool **82** and passages **86, 87**, by a bellows operated plunger **88** responding to sensor **89** disposed in the supply chamber **14'**. When the temperature of the nozzle **12'** reaches a predetermined value the fuel passing therethrough will cause the temperature to rise in the supply chamber **14'** and thus by choosing the correct thermostatic valve (or adjusting an adjustable version thereof) the normal supply pump flow will occur through the nozzles and supply chamber upon the temperature of the injector reaching a predetermined desired minimum temperature. Thereafter the cooling flow through the system will prevent excessive injector temperatures. When the thermostatic valve **81** is used, a pump relief valve **91** is required to prevent excessive pressure buildup during the interval of time that the valve **81** is in its closed position as illustrated. A bleed hole or passage **92** is provided in housing **16'** to insure a small flow of fuel even when the valve **81** is closed and thus the supply chamber will be vented of air or gases.

In FIG. 4 I also illustrate a novel means for providing cooling flow through the nozzles after engine shut down. An engine fuel shut off control **101** is connected to the fuel pump **11'** by suitable linkage **102** and when moved to its engine shut down (fuel shut off) position it activates a time control switch **103** through link **104**. The switch **103** connects an electric motor **106** to the vehicle battery, not shown, and the motor **106** drives auxiliary pump **137** for a predetermined interval of time after engine shut down thus delivering fuel to conduits **41'** connected, respectively, with a plurality of nozzles **12'**, only one of which is illustrated. It is possible to use a single supply pump **237** as shown in FIG. 5, with an overriding clutch **238** between the engine power take off shaft **239** and pump **237** and with an overriding clutch **241** between pump **237** and electric motor **211**. As in the FIG. 1 embodiment of my invention, each injector **12'** is connected to a delivery line **26** and the injection pump **11'** is of the precharged type similar to pump **11**. The automatic cooling of nozzles after engine shut down will prevent excessive heating (cooking) of the fuel in the cavity **49** of the inwardly opening nozzle and cavity **67** of the outwardly opening nozzle. Cooking of the fuel may results in cracking of the fuel and formation of carbon and tar deposits, which of course is quite detrimental to proper nozzle functioning.

My counter flow fuel injection system provides cooling of not only the injector nozzles but also the pump head **90** and plunger **19**. During operation there is flow of fuel from the supply pump through the delivery passages in the head and recess **17** and groove **18** in the plunger to provide continuous cooling of the pump head and plunger which are subjected to considerable heat due to compression of fuel in chamber **23**, for instance as high as 10,000 p.s.i. peak pressure. There is continuous cooling of the pump head even during injection since injection occurs through one delivery passage at a time while the other delivery passages are serving as cooling passages. Thus the mass of head **90** is continuously cooled to effectively prevent phenomena detrimental to the filling of pumping chamber **23** such as vapor lock.

Cooling of the nozzles and pump head will not be necessary at low engine speeds and loads, however cooling is desired when engine load and speed increases. The temperature of the fuel supplied to the pump supply chamber via the nozzles will be indicative of the temperature of the nozzles; therefore, the nozzle temperature can be sensed in the supply chamber of the injection pump and the cooling flow governed accordingly.

Without any provision for nozzle cooling, the nozzle installation should be such as to result in tolerable temperatures at high engine speed and load. Therefore the temperatures at low engine speed and load may tend to be too low with an engine of high horsepower rating (for instance a turbocharged engine). This may result in acid corrosion of injector parts if such an engine is subjected to long periods of idle operation. Hence the advantage of my thermostatically controlled cooling flow.

The embodiments of the invention for which an exclusive property or privilege is claimed are defined as follows:

1. A fuel injection system for a multicylinder engine, comprising:

- a distributor type fuel injection pump having
  - a supply chamber,
  - a high pressure chamber,
  - a bore opening into said high pressure chamber,
  - a plurality of delivery passages,
  - a reciprocating plunger in said bore for cyclically pressurizing fuel in said high pressure chamber, and
  - means cyclically connecting said delivery passages one at a time to said high pressure chamber and connecting said delivery passages to said supply chamber when the latter are not connected to said high pressure chamber,
- a fuel injection nozzle for each engine cylinder, each nozzle having
  - a body with a pressure cavity,
  - a pressure responsive valve for delivering fuel from said pressure cavity to an engine cylinder associated with said nozzle, first and second branch passageways in said body connected to and extending from said cavity, and
  - check valve means in said first passageway permitting flow therethrough in the direction toward said cavity and preventing flow in the opposite direction,
  - a fuel supply pump delivering fuel from a fuel source to said first passageways of said nozzles,
  - conduits connecting said second passageways of said nozzles to said delivery passages, respectively, and
  - conduit means connecting said supply chamber to said source.

2. The structure set forth in claim **1** and further comprising a pressure regulating valve in said conduit means connecting said supply chamber to said source for maintaining the pressure of fuel in said supply chamber at an intermediate pressure above atmospheric pressure and substantially below injection pressure.

3. The structure set forth in claim **1** wherein said pressure responsive valves of said nozzles are outwardly opening valves.

4. The structure set forth in claim **3** wherein said check valve means includes a flexible diaphragm covering the terminus of said first passageway at said cavity.

5. The structure set forth in claim **1** and further comprising flow control means for preventing normal flow of fuel from said supply chamber to said source until the temperature of fuel returning from said nozzles exceeds a predetermined minimum.

6. The structure set forth in claim **5** wherein said flow control means includes a temperature responsive valve in said conduit means connecting said supply chamber to said source.

7. The structure set forth in claim **6** wherein said flow control means includes a bleed passage permitting limited flow from said supply chamber to said source when said temperature is below said predetermined minimum.

8. The structure set forth in claim **6** and further comprising a pressure relief valve for connecting the outlet of said pump to the inlet of said pump when the pressure exceeds a predetermined value.

9. The structure set forth in claim **6** wherein said flow control means includes a temperature sensor disposed in part in said supply chamber and operatively connected in actuating relation to said temperature responsive valve.

10. In an injection system for a multiple cylinder engine, the combination comprising:

- a plurality of fuel nozzles for injecting fuel into each said cylinder,
- a pressure operated valve in each of said nozzles for controlling flow of fuel from said nozzles to said engine cylinders,

an engine driven fuel supply pump for continuously pumping fuel directly through the bodies of each of said nozzles,

conduit means connecting said supply pump to said nozzles whereby said nozzles are connected in parallel,

an engine driven distributor type fuel injection pump for cyclically delivering high pressure fuel to said nozzles by way of a plurality of fuel delivery passages, and

a plurality of conduits connecting said nozzles to said delivery passages, respectively, said conduits and injection pump normally forming unobstructed pathways permitting fuel to flow to said nozzles from said injection pump during injection periods and from said nozzles to said injection pump during noninjection periods.

11. The structure set forth in claim **10** and further comprising pump means for automatically pumping fuel through said nozzles to cool the same for a predetermined time interval upon engine shutdown.

12. The structure set forth in claim **11** and further comprising check valve means at each of said nozzles preventing flow from said nozzle to said supply pump by way of said conduit means.

13. The structure set forth in claim **12** and further comprising pressure regulating means causing the pres-

sure in said conduits to be substantially above atmospheric pressure and substantially below injection pressure during noninjection intervals.

14. The structure set forth in claim **12** wherein said nozzle is of the outward opening type.

15. The structure set forth in claim **12** and further comprising temperature responsive valve means for substantially preventing flow from said nozzles through said conduits when said fuel in said nozzles is below a predetermined temperature and pressure relief means for said supply pump.

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