

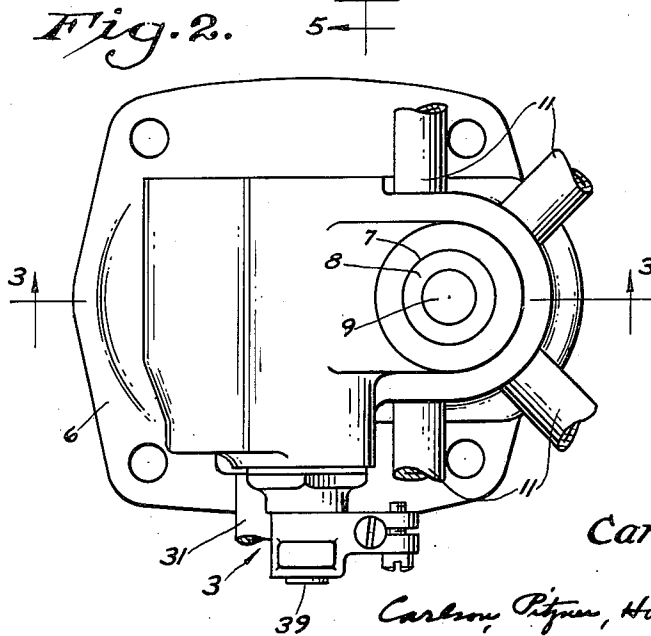
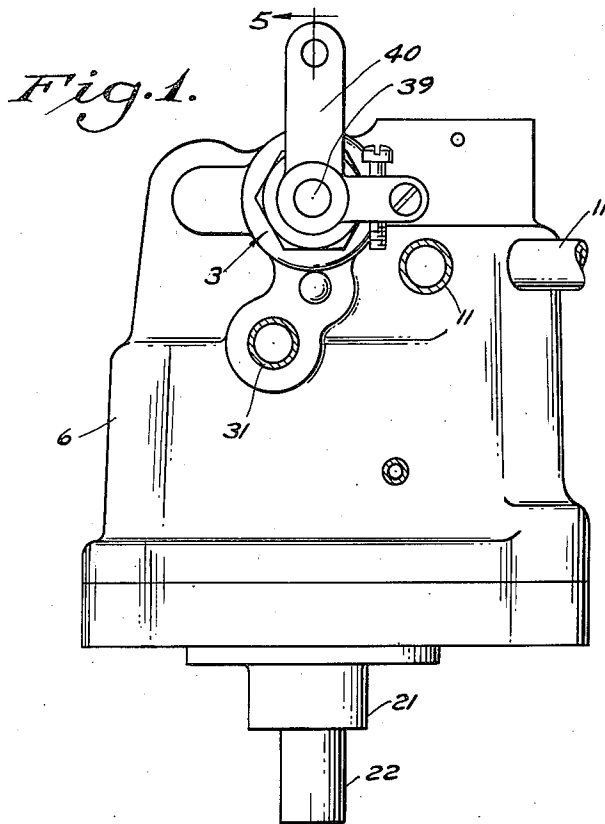
April 8, 1952

C. F. HIGH
FUEL INJECTION PUMP

2,592,281

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4 Sheets-Sheet 1



Inventor
Carl F. High
By
Carlson, Pitman, Hubbard & Wolfe
Attorneys.

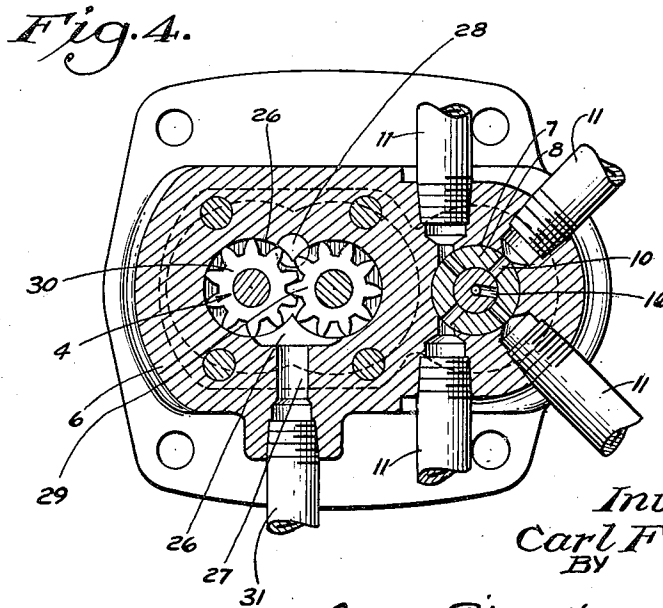
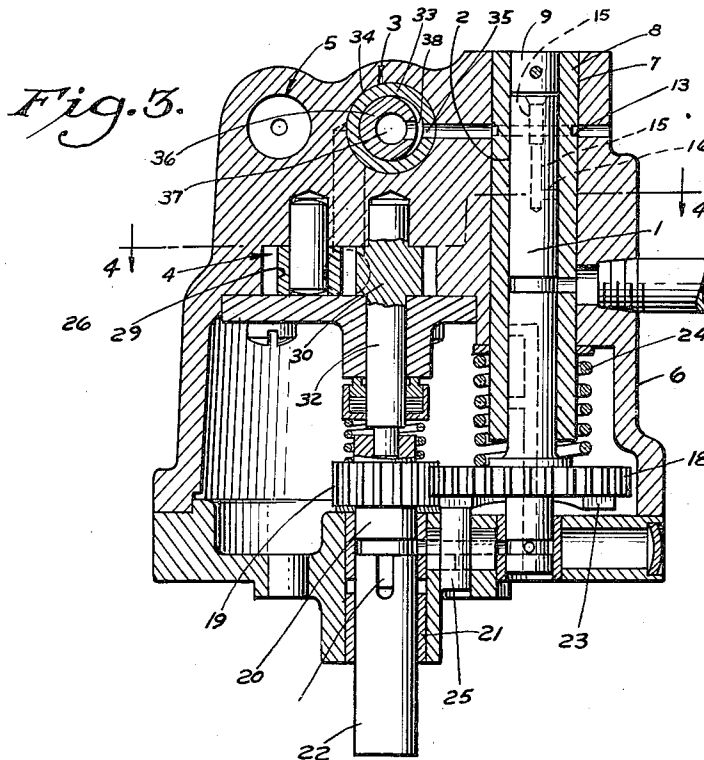
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Inventor
Carl F. High
BY

Carlson, Pitman, Hubbard & Wolfe
Attorneys

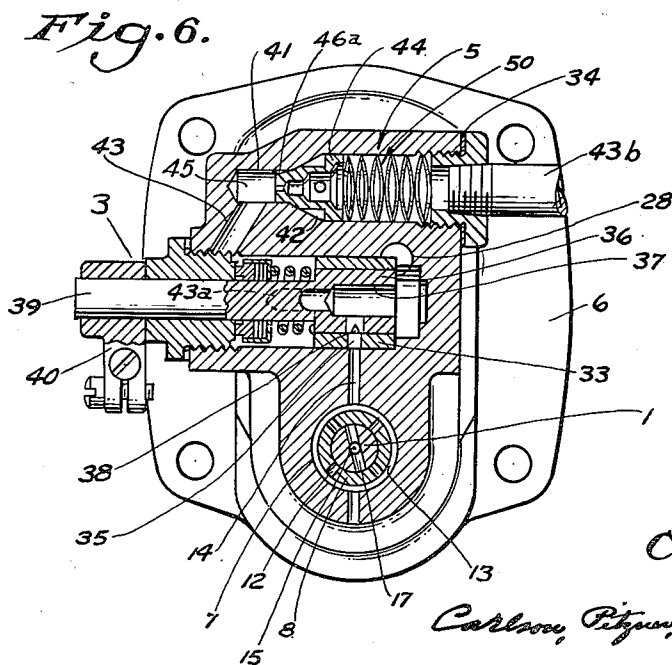
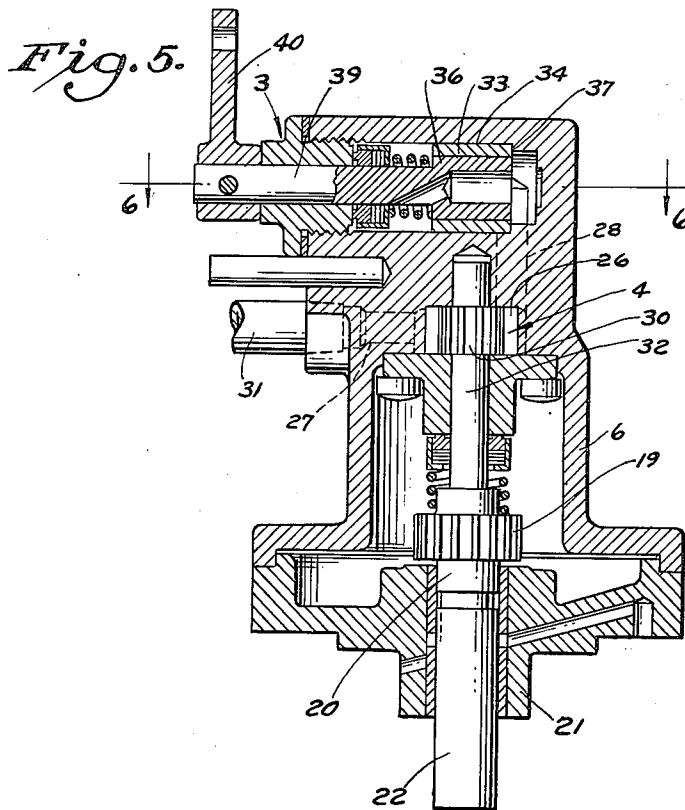
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Inventor
Carl F. High
BY
James H. Hubbard & Wolfe
Attorneys.

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C. F. HIGH

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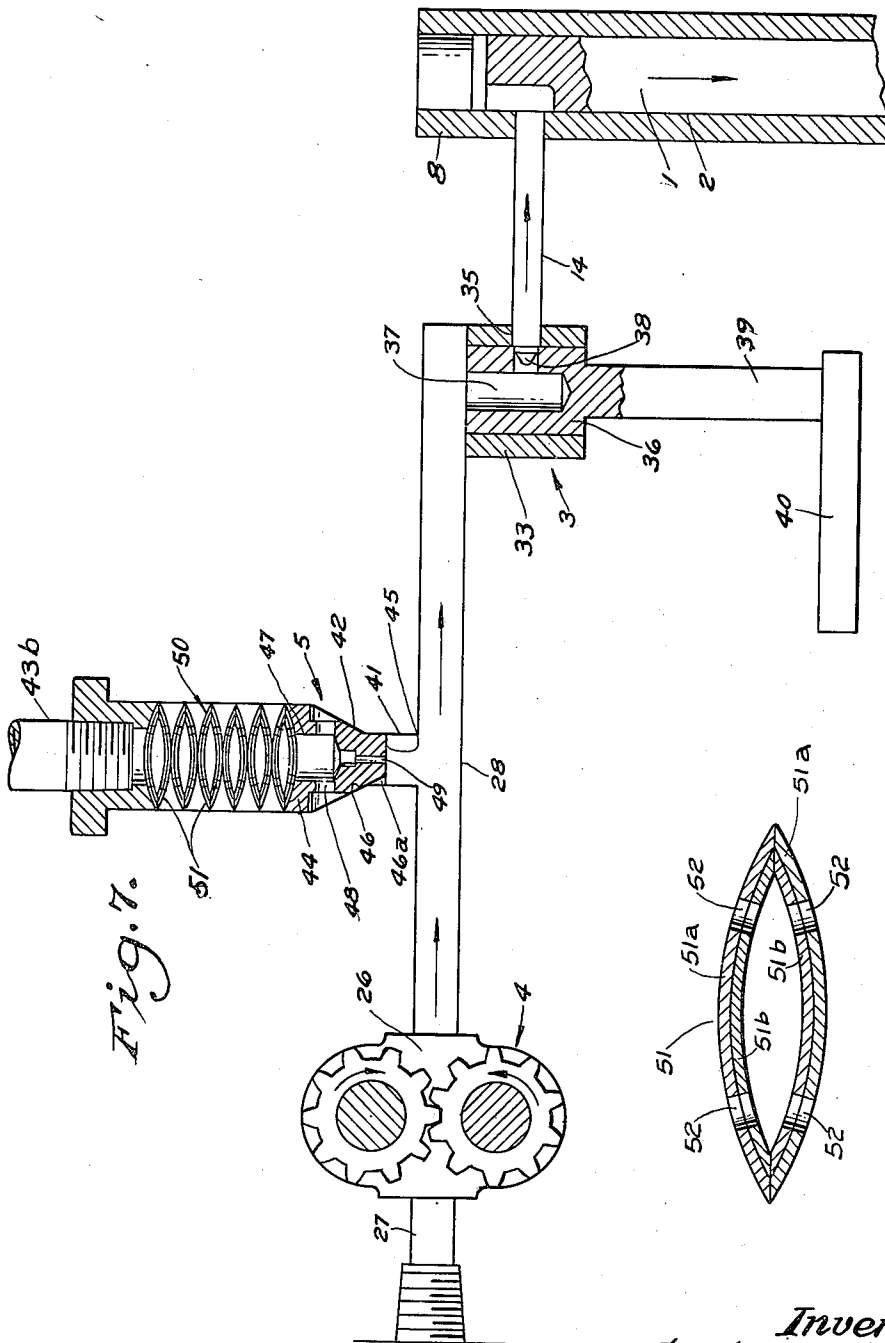


Fig. 7.

Fig. 8

Inventor
Carl F. High
BY

Carlson, Piquet, Hubbard & Wolfe
Attorneys

UNITED STATES PATENT OFFICE

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FUEL INJECTION PUMP

Carl F. High, Detroit, Mich., assignor, by mesne assignments, to American Bosch Corporation, Springfield, Mass., a corporation of New York

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12 Claims. (Cl. 103—41)

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The present invention relates to improvements in fuel injection pumps of the suction-metered type.

One of the objects of the present invention is to provide a new and improved fuel injection pump in which fuel is metered in an adjustable predetermined quantity into the pump chamber without variation regardless of changes in the fuel temperature.

Another object is to provide a novel suction-metered pump having thermostatic means automatically operable to compensate for changes in fuel temperature so as to maintain the fuel input constant.

A further object is to provide, in a suction-metered fuel pump having a metering throttle controlling the rate of fuel supply, a pressure relief valve for normally maintaining a predetermined pressure at the up-stream side of the throttle, and operable to vary said pressure in response to and accordance with changes in the temperature of the fuel passing therethrough, whereby to maintain a substantially constant pressure drop across the throttle regardless of temperature induced pressure fluctuations at the down-stream side.

Other objects and advantages will become apparent as the description proceeds.

Figure 1 is a side elevational view of a fuel injection pump embodying the features of my invention.

Fig. 2 is a plan view of the pump.

Fig. 3 is a longitudinal sectional view taken along line 3—3 of Fig. 2.

Fig. 4 is a transverse sectional view taken along line 4—4 of Fig. 3.

Fig. 5 is a longitudinal sectional view taken along line 5—5 of Fig. 1.

Fig. 6 is a transverse section view taken along line 6—6 of Fig. 5.

Fig. 7 is a diagrammatic representation of the fuel system constituting the pump.

Fig. 8 is an enlarged sectional detail view.

Referring more particularly to the drawings, the pump, constituting the exemplary embodiment of the invention, is of the section-metered type, in which a pump plunger 1 is reciprocable in a cylinder 2, and in which a variable quantity of fuel is supplied under suction through an adjustable throttle 3 to the cylinder during the intake stroke of the plunger, and is discharged therefrom to a delivery port or passage during the pressure stroke of the plunger. An excess of fuel is supplied to the system by a transfer pump 4, and is available at the inlet of the throttle

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3 at a predetermined pressure maintained by a relief valve 5. The fuel in excess of the quantity supplied through the throttle 3 to the pump cylinder 2 is diverted or by-passed through the relief valve 5, preferably back to the inlet of the pump 4.

During the intake stroke of the pump plunger 1, the pressure in the cylinder or pump chamber 2 and hence at the outlet of the regulating throttle 3 is less than the pressure at the inlet of the throttle. Under all conditions when the quantity of fuel supplied to the chamber is less than the volumetric displacement of the plunger 1, the intake pressure is the absolute vapor pressure of the fuel at the prevailing temperature. It will be understood that the pressure differential across the throttle 3 for any given throttle area determines the rate of fuel flow, and for a given time the quantity of fuel supplied, to the pump chamber 2.

In a broad sense, the pump comprises a pumping chamber, herein disclosed as the cylinder 2, and a pumping element, herein shown as the plunger 1, operable therein to take in fuel through the throttle 3 in metered quantities equal to or less than the pump displacement, and to discharge the fuel under pressure to the delivery passage.

Changes in temperature of the fuel, particularly high volatile fuels, such as aviation gasoline, will result in changes in the fuel vapor pressure, thus altering the pressure differential across the throttle 3, and thereby varying the actual quantity of fuel supplied for any given adjustment. For example, the fuel pump will experience a decrease in effective capacity or quantity of delivery upon an increase in the fuel temperature. Such variation in actual fuel delivery upsets or disturbs the calibration of the fuel quantity control mechanism, and results in an objectionable and unpredictable change in the established air-fuel ratio.

To overcome the foregoing difficulty, the present fuel pump is provided with novel means which is automatically operable to maintain the quantity of fuel delivery constant for any given volume adjustment regardless of changes in the temperature of the fuel, and which, more specifically, is temperature responsive to effect a compensation for any changes in the fuel vapor pressure so as to maintain an established pressure drop across the throttle 3. Such compensation may be accurately obtained in a simple and convenient manner by varying the pressure at the inlet to the throttle 3 automatically in direct proportion

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to changes in the temperature of the fuel supplied by the transfer pump 4, and therefore in direct proportion to the absolute vapor pressure in the cylinder 2, so as to maintain the pressure drop or differential constant.

The pump, in the particular type and form shown for purposes of illustration, comprises a suitable housing 6 adapted to be mounted on a support, such for example as an engine block (not shown). The housing 6 is formed with a bore 7 in which a tubular sleeve 8 is inserted to define the cylinder 2. One end of the sleeve 8 is suitably closed by a plug 9, and the other end receives the plunger 1. In the present instance, only one plunger 1 is shown, but it is to be understood that any desired number of such pumping units may be provided.

The plunger 1 serves not only as the pumping element, but also to control alternate communication of the cylinder with the fuel inlet and outlet ports, and to perform the last function is rotatable in timed relation to the reciprocation.

The pump may have any desired number of delivery lines, depending for example on the number of engine cylinders that are to be served, and where more than one such delivery line is provided, the plunger 1 in its rotation operates as a distributor. In the present instance, the cylinder sleeve 8 is formed in one transverse plane with four uniformly peripherally spaced delivery ports 10 connected respectively to discharge lines 11 (Fig. 4). The cylinder sleeve 8 is also formed in another transverse plane (Fig. 6) with a corresponding number of inlet ports 12 connected in common through a peripheral groove 13 to an inlet or supply passage 14.

Preferably, the plunger 1 is formed with a passage for connecting the pump chamber 2 in sequence to the delivery ports 10 during successive pressure strokes, and alternately to the inlet ports 12 during successive suction or intake strokes. This passage comprises an axial bore 15 opening to the chamber 2, and connected at the inner end to a radial distributor port 16 in the general plane of the delivery ports 10, and intermediate its ends to radial supply ports 17 in the general plane of the inlet ports 12. The porting is of such angular phase relationship that communication for fuel inlet and discharge is uniformly alternated.

The pump plunger 1 is adapted to be continuously rotated through a gear 18 rigid therewith, and meshing with a wider gear 19 on a stub shaft 20 journaled in a bearing 21 in the housing 6. A drive shaft 22, which may be connected to a suitable source of power, such for example as an engine (not shown) adapted to be served by the pump, also is journaled in the bearing 21, and is keyed for joint rotation to the shaft 20.

Reciprocation may be imparted to the pump plunger 1 by any suitable means in timed relation to the rotation so that the ports 17 will connect with certain of the inlet ports 13 during each outward stroke and likewise the port 16 will communicate with one of the delivery ports during each inward or pressure stroke.

It will be understood that the number of reciprocations during each revolution should conform to the number of delivery ports 10. In the present instance, reciprocation is effected by an annular end face cam 23 rigid and concentric with one side of the gear 18, and formed with four uniformly peripherally spaced lobes. The cam 23 is held by a coil compression spring 24 in operative engagement with a follower roller 25 jour-

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nalled in the housing 6. The rise of the cam lobes determines the volumetric displacement of the plunger 1, this displacement or travel being fixed in the present instance regardless of whether or not the cylinder space is filled in each suction stroke.

Also enclosed in the housing 6 is the transfer pump 4 which may be of any suitable type and driven by any desired means to supply fuel at low pressure and in an amount in excess of the volumetric displacement of the plunger 1. In the present instance, the pump 4 comprises a chamber 26 having an inlet passage 27 and an outlet passage 28, and two inter-meshing spur gears 29 and 30. The passage 27 is adapted to be connected through a line 31 to a suitable fuel source (not shown). The gear 30 has a shaft 32 coupled for joint rotary drive to the stub shaft 20.

The outlet passage 28 of the pump 4 is connected through the regulating valve 3 to the pump inlet passage 14, these passages constituting the suction-metered supply passage for the pump 1, 2. The valve 3 preferably is of the orifice type adapted to govern the rate of fuel supply in accordance with the difference in pressure at the inlet and outlet, i. e. in accordance with the difference between the effective delivery pressure of the pump 4 and the lower liquid or absolute vapor pressure in the pump cylinder 2 during each intake stroke of the plunger 1. In its preferred form, the valve 3 comprises a sleeve 33 fixed in a bore 34 in the housing 6 and having a radial port 35 open to the passage 14. Rotatable in the sleeve 33 is a valve member 36 which is formed with an axial bore 37 open to the passage 28. The valve member 36 is also formed in the periphery with a tapered partial circumferential groove 38 connected to the bore 37 and in registration with the port 35. It will be seen that the port 35 and groove 38 define a restricted flow orifice. To provide means for adjusting the effective flow area of the orifice 35, 38, and thereby to control its rate of fuel supply to the cylinder 2, the valve member 36 is formed with a shaft 39 extending to the exterior of the housing 6 for connection to a suitable throttle control linkage 40.

The pressure at the inlet to the throttle 3 is normally maintained at a predetermined pressure by the relief valve 5 for a given fuel temperature. As a consequence, a pressure drop or differential is established across the throttle determining the rate of fuel flow to the cylinder 2 in accordance with the flow law of orifices. The relief valve 5 may be of any suitable character, and in the present instance comprises a valve passage 41 formed with a tapered valve seat 42. One end of the passage 41 at the upstream side of the seat 42 is connected to the passage 28 via a bore 43 to one end of the bore 34 and a port 43a to the bore 37 opening to the other end of the bore 34, and the other end is connected to a line 43b adapted to lead to a fuel sump (not shown), adapted to receive excess fuel spilling through the valve 5. Preferably, this sump is the source of fuel supply for the pump 4.

The valve passage 41 consists of a bore enlarged at the down-stream side of the seat 42. Slidably disposed in the enlarged portion of the bore 41 is a valve member 44 having a cylindrical pilot extension 45 in the reduced portion of the bore and a conical valve face 46, Fig. 7, adapted for engagement with the seat 42. One side of the extension 45 is formed with a groove 46a defining a flow passage when the valve 5 is open. The valve member 44 is formed with a stepped

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bore 47 opening through a port 48 to the seat 42 so as to provide a free path of fuel flow from the seat to the line 43b. Preferably, the bore 47 is connected to the passage 28 through a small aperture 49 so that a restricted quantity of fuel will flow through the valve 5 at all times.

The valve member 44 is normally urged toward and into engagement with the seat 42 by a spring means 50 in the enlarged portion of the bore 41. In the present instance, the spring means is so constituted that its action will vary automatically in response to variations in the temperature of the fuel passing through the valve 5. In other words, the spring means 50 is temperature responsive so that the valve closing force and hence the pressure in the passage 28 will rise as the fuel temperature rises, and will decrease as the temperature drops.

To this end, a bi-metallic spring means is provided. Preferably, the spring means 50 comprises a series of bi-metallic resilient disks 51 confined in the passage 41 in pressure engagement with the valve member 44. Each disk comprises a composite of two layers of metal 51a and 51b (Fig. 8) having different coefficients of temperature expansion, and is circular in outline and centrally dished or concave. Successive disks 51 are oppositely disposed so as to contact with each other either at the periphery or alternately at the center in axially aligned series. Preferably, each disk 51 is formed with a series of apertures 52 to permit the free flow of fuel therethrough, thus maintaining them in direct contact with the excess fuel by-passed by the valve and sensitively responsive to changes in fuel temperature.

Upon an increase in fuel temperature, the concavity of each disk 51 will increase, thereby tending to increase the overall length of the disk assembly, and the valve closing spring pressure. Upon a decrease in pressure, the opposite effect will be obtained.

In operation, the pressure at both sides of the throttle 3 will remain constant as long as the fuel temperature remains unchanged. Should the fuel temperature vary, the vapor pressure in the cylinder 2 and hence the pressure at the down-stream side of the throttle 3 will vary accordingly. Thus, an increase in fuel temperature will increase the vapor pressure in the cylinder 2 if the throttle 3 is set for a partial charge less than the maximum displacement of the plunger 1, thereby tending to reduce the pressure differential across the throttle, and hence the quantity of fuel supplied for each charge.

However, this rise in temperature will effect an increase in the closing force of the spring means 50 to cause a corresponding rise in the pressure at the inlet of the throttle 3, thus maintaining the pressure differential resulting in fuel flow substantially constant. Since this pressure differential is maintained for any given setting of the throttle 3, a constant quantity of fuel will enter the cylinder 2 as a charge during each intake stroke of the plunger 1 regardless of variations in fuel temperature.

I claim as my invention:

1. A liquid fuel injection pump comprising, in combination, a housing having a pump chamber with a fuel inlet and a discharge outlet, a pumping element operative in said chamber and adapted to induce the supply of fuel into said chamber through said inlet and to discharge fuel under pressure from said chamber through

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said outlet, conduit means for supplying fuel to said inlet under pressure, a pressure relief valve communicating with said conduit, a temperature responsive control operatively associated with the pressure relief valve to vary the release pressure of the valve proportionally to the fuel temperature, said pressure relief valve serving to regulate the fuel pressure in the conduit in such a manner that said pressure will vary proportionately to the fuel temperature.

2. The fuel pump of claim 1 having an adjustable throttle orifice in the conduit between the pressure relief valve and the fuel inlet to the pump chamber for varying the rate of fuel flow into the pump chamber.

3. A fuel pump comprising, in combination, a housing, a pump cylinder in said housing and having a suction inlet port and a delivery outlet port in peripherally spaced relation, a pump plunger being reciprocable in said cylinder, and each complete reciprocation comprising an intake stroke and a pressure stroke, and being simultaneously rotatable in timed relation to said reciprocation to connect said cylinder to said inlet port during an intake stroke and to said outlet port during a pressure stroke, means for reciprocating and rotating said plunger, a transfer pump in said housing and having an inlet passage and a delivery passage connected to said inlet port, an adjustable regulating valve interposed in said delivery passage and defining a throttle orifice for controlling the flow of fuel to said cylinder, and a by-pass pressure relief valve opening from said delivery passage between said transfer pump and said regulating valve for diverting excess fuel back to said inlet passage, said relief valve comprising a valve passage having an outwardly facing valve seat, an outwardly opening valve member adapted for engagement with said seat, and a plurality of resilient bi-metallic disks stacked in abutting face-to-face relation within said valve passage and exerting a spring action against said valve member tending to close the latter.

4. A liquid fuel injection pump comprising, in combination, a housing having a pump cylinder defining a chamber having a suction inlet and a pressure outlet, a pump plunger reciprocable in said cylinder to induce the supply of fuel through said inlet during an intake stroke and the discharge of a complete or partial charge of fuel under pressure through said outlet during each pressure stroke, a supply passage adapted to receive liquid fuel under pressure and opening to said inlet, a flow metering device interposed in said passage and adapted to create a pressure differential in the flow of fuel to said inlet during each intake stroke, and a relief valve opening from said passage at the upstream side of said device normally to maintain a predetermined pressure for a given temperature in said passage, said valve comprising thermostatic spring means tending to close said valve and adapted to vary in spring force in accordance with changes in the temperature of the fuel passing therethrough.

5. A fuel pump comprising, in combination, a housing, a pump cylinder in said housing and having a suction inlet port and a delivery outlet port in peripherally spaced relation, a pump plunger being reciprocable in said cylinder, and each complete reciprocation comprising an intake stroke and a pressure stroke, and being simultaneously rotatable in timed relation to said reciprocation to connect said cylinder to

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said inlet port during an intake stroke and to said outlet port during a pressure stroke, means for reciprocating and rotating said plunger, a transfer pump in said housing and having an inlet passage and a delivery passage connected to said inlet port, an adjustable regulating valve interposed in said delivery passage and defining a throttle orifice for controlling the flow of fuel to said cylinder, and a by-pass pressure relief valve opening from said delivery passage between said transfer pump and said regulating valve for diverting excess fuel back to said inlet passage, said relief valve being responsive to vary the pressure in said passage proportionately to changes in the temperature of the fuel passing through said orifice.

6. A liquid fuel injection pump comprising, in combination, a housing having a pump chamber with a fuel inlet and a discharge outlet, a pumping element operative in said chamber adapted to induce the supply of fuel into said chamber through said inlet and to discharge fuel under pressure from said chamber through said outlet, a supply passage adapted to receive liquid fuel under pressure and opening to said inlet, a flow metering device interposed in said passage and adapted to create a pressure differential in the flow of fuel to said inlet, and a relief valve opening from said passage at the up-stream side of said device normally to maintain a predetermined pressure for a given temperature in said passage, said valve comprising thermostatic spring means tending to close said valve and adapted to vary in spring force in accordance with changes in the temperature of the fuel passing therethrough.

7. A liquid fuel injection pump comprising, in combination, a housing having a pump chamber with a fuel inlet and a discharge outlet, a pumping element operative in said chamber and adapted to induce the supply of fuel into said chamber through said inlet and to discharge fuel under pressure from said chamber through said outlet, means for supplying liquid fuel to said inlet, an adjustable throttle orifice in said fuel supplying means for regulating the rate of fuel flow to said pump chamber, and temperature responsive means in thermal contact with the fuel and operatively associated with said supplying means on the up-stream side of said orifice for varying the fuel pressure in said supplying means on said up-stream side of said orifice proportionately to the fuel temperature for maintaining the rate of flow through said orifice substantially constant regardless of variations in the fuel temperature.

8. A liquid fuel injection pump comprising, in combination, a housing having a pump cylinder defining a chamber having a suction inlet and a pressure outlet, a pump plunger reciprocable in said cylinder to induce the supply of fuel through said inlet during an intake stroke and the discharge of a complete or partial charge of fuel under pressure through said outlet during a pressure stroke, a supply passage opening to said inlet, a control device including an adjustable throttle orifice interposed in said passage for metering the supply of fuel to said inlet, and means for automatically compensating the action of said device in response to variations in fuel temperature, whereby to maintain the quantity of fuel flow through said orifice substantially constant, said last-mentioned means comprising a relief valve communicating with a portion of said passage on the side of said orifice opposite

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from said inlet, said valve being automatically operable to open and divert excess fuel from said portion of said passage in response to an increase in fluid pressure therein above a predetermined level, a temperature responsive actuating member coacting with said valve, and said valve having a diverting orifice of small flow area permitting a constant minimum diversion of fuel to flow over said actuating member, said actuating member being responsive to temperature changes in the fuel to vary said predetermined pressure level proportionately to variations in the fuel temperature.

9. A liquid fuel injection pump comprising, in combination, a housing having a pump chamber with a fuel inlet and a discharge outlet, a pumping element operative in said chamber adapted to induce the supply of fuel into said chamber through said inlet and to discharge fuel under pressure from said chamber through said outlet, a supply passage opening to said inlet, a control device including an adjustable throttle orifice interposed in said passage for metering the supply of fuel to said inlet, and means for automatically compensating the action of said device in response to variation in fuel temperature, whereby to maintain the quantity of fuel flow through said orifice substantially constant, said last-mentioned means comprising a relief valve adapted to open in response to a rise above a predetermined level in the fuel pressure in the portion of said passage on the up-stream side of said orifice to divert excess fuel from said portion and thereby limit the pressure therein substantially to said predetermined level, said relief valve having a diverting orifice of small flow area permitting constant minimum diversion of fuel, and a temperature responsive valve actuating member interposed in the path of fuel diverted through said last mentioned orifice, said actuating member coacting with said valve to vary said predetermined opening pressure level proportionately to variations in the temperature of the fuel.

10. A liquid fuel injection pump comprising, in combination, a housing having a pump cylinder defining a chamber having a suction inlet and a pressure outlet, a pump plunger reciprocable in said cylinder to induce the supply of fuel through said inlet during an intake stroke and the discharge of a complete or partial charge of fuel under pressure through said outlet during a pressure stroke, a supply passage adapted to receive liquid fuel under pressure and opening to said inlet, a flow metering device interposed in said passage and adapted to create a pressure differential in the flow of fuel to said inlet during said intake stroke, and a relief valve opening from said passage at the up-stream side of said device, said valve having a thermostatically controlled element therein for varying the release pressure of the relief valve proportionally to the fuel temperature, said valve normally maintaining a predetermined fluid pressure in said up-stream side of said passage and being operable to vary said fluid pressure proportionally in response to changes in the fuel temperature.

11. A liquid pump comprising, in combination, a housing having a pump cylinder defining a chamber having a suction inlet and a pressure outlet, a pump plunger reciprocable in said cylinder to induce the supply of fuel through said inlet during an intake stroke and the discharge of a complete or partial charge of fuel under pressure through said outlet during a pressure stroke,

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a supply passage adapted to receive liquid fuel under pressure and opening to said inlet, a flow metering device having a variable orifice interposed in said passage and adapted to create a pressure differential in the flow of fuel to said inlet during each intake stroke, and means communicating with said passage on the upstream side of said orifice for automatically varying the fluid pressure in the contiguous portion of the passageway to maintain said pressure differential constant for varying fuel temperatures regardless of reflected variations in the absolute fuel vapor pressure in said chamber.

12. A liquid fuel injection pump comprising, in combination, a housing having a pump chamber with a fuel inlet and a discharge outlet, a pumping element operative in said chamber and adapted to induce the supply of fuel into said chamber through said inlet and to discharge fuel under pressure from said chamber through said outlet, means for supplying liquid fuel to said inlet, and temperature responsive control means associated with said supplying means for normally maintaining a predetermined fluid pres-

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sure in said supplying means for a given temperature of the fuel therein, said control means being arranged to have thermal contact with the fuel in said supplying means and being responsive to temperature changes in the fuel to progressively vary the fuel pressure in said supplying means proportionately to said temperature changes, said control means thus compensating for variations in the fuel temperature to maintain the fuel flow to the pump virtually unaffected by such temperature changes.

CARL F. HIGH.

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