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FUEL INJECTION SYSTEM

Filed May 7, 1958 2 Sheets-Sheet 1

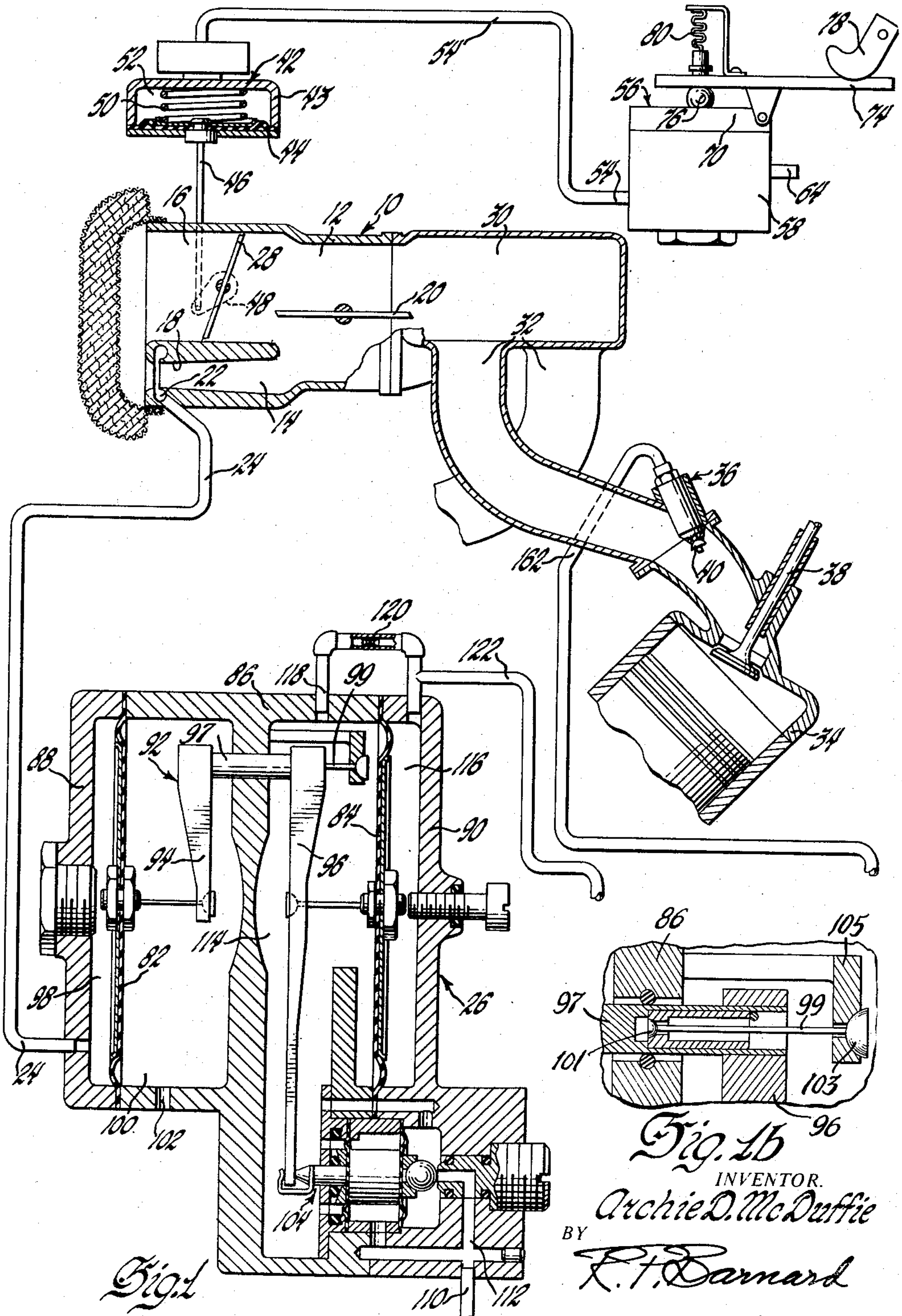

Fig.1

Fig.1b

INVENTOR.

Archie D. McDuffie

BY

R. T. Barnard

ATTORNEY

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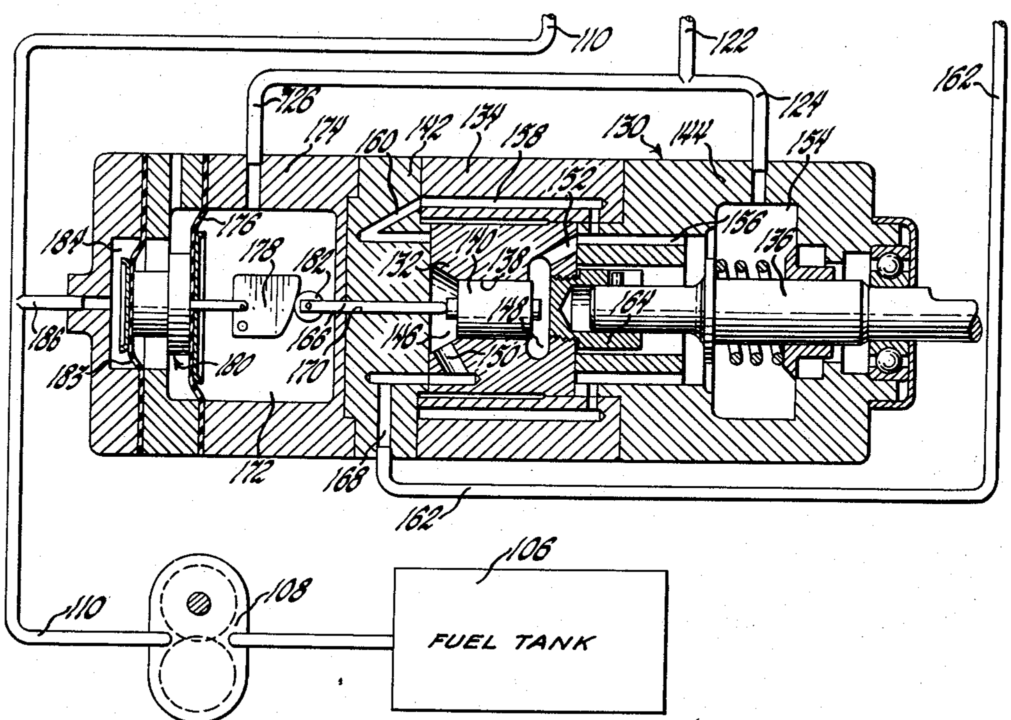

Fig. 1a

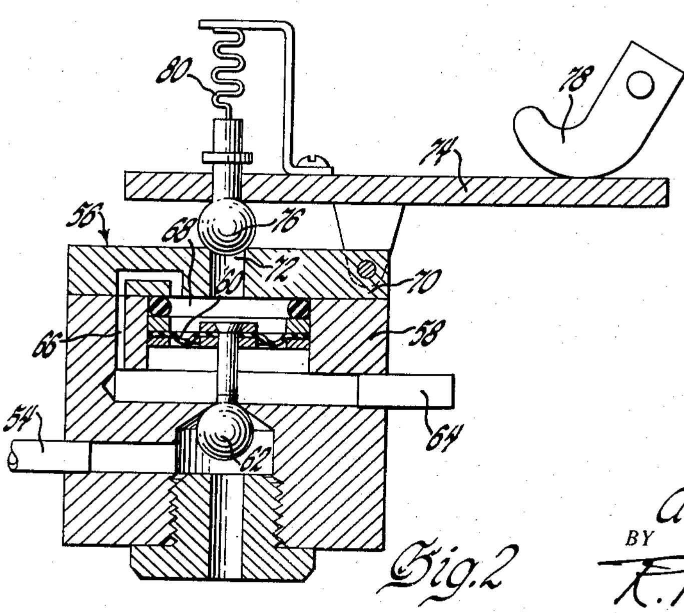

Fig. 2

INVENTOR.
Archie D. McDuffie
BY
R. F. Barnard
ATTORNEY

United States Patent Office

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1

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FUEL INJECTION SYSTEM

Archie D. McDuffie, Berkley, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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The present invention relates to a fuel injection system in which the quantity of fuel supplied to the individual cylinders of the engine is determined by mass air flow. More specifically, the present fuel system embodies a ful distributing device in which the mass air flow metered fuel is delivered to the individual engine cylinders in quantities timed to engine speed.

While the mass air flow control system may be of any well known type, the present invention has been illustrated with the system shown in copending application Serial No. 634,915 McDuffie, filed January 18, 1957 on which Patent No. 2,893,711 issued July 7, 1959. The mechanism for distributing timed charges of fuel to the individual cylinders of the engine is preferably of the shuttle piston type which has been uniquely combined with a mass air flow controlled system. In this type of distributor a reciprocating piston is employed which alternately supplies fuel to one-half the engine's cylinders from its respective ends. By alternately supplying fuel to the respectvie ends of the shuttle piston, one end is charged with fuel while the other is supplying its cylinders with cycle being reversed in timed relation to engine speed.

The present invention in uniquely combining mass air flow fuel metering and shuttle piston timed fuel distributing has resulted in a fuel injection system which more nearly meets the standards of economy of manufacture and preciseness of fuel metering than has heretofore been realized.

Other objects and advantages of the present invention will be apparent from a perusal of the detailed description which follows:

In the drawings:

Figures 1, 1*a* and 1*b* are sectional views of the subject invention; and

Figure 2 is an enlargement of the secondary throttle switch mechanism.

Referring to the drawings, an air induction casing is shown at **10** and includes an air induction passage **12** having a pair of parallel related passages **14** and **16**. The smaller passage **14** includes a venturi **18** formed therein and continuously supplies air therethrough in accordance with the position of a primary throttle valve **20**. Valve **20** is disposed within induction casing **10** posteriorly of passages **14** and **16**.

An annular chamber or piezometer ring **22** is formed in casing **10** in open communication with the throat of venturi **18**. Ring **22**, in turn, is communicated with a conduit **24**. A vacuum force is created in ring **22** which is proportional to the square of air flow velocity through passage **14**. The vacuum force is, in turn, supplied by conduit **24** to a fuel metering mechanism indicated generally at **26** which, infra, meters fuel in accordance with the aforenoted mass air flow.

A secondary throttle **28** is provided in the large intake passage **16** and is adapted to be opened to supply air under high air flow conditions.

Induction casing **10** communicates with a plenum or manifold chamber **30**. A plurality of intake passages **32** communicate with plenum chamber **30** for supplying air to the individual engine cylinders **34**. A fuel nozzle **36** is disposed in each intake passage **32** proximate the cylinder intake valve **38** for supplying metered and timed quantities of fuel to the cylinder.

2

In the event the subject system is maintained under a superatmospheric pressure, nozzles **36** may be of the pressure responsive type in which a spring biased valve **40** will enable the system to be pressurized. Valve **40** will open when the fuel pressure exceeds a predetermined minimum value.

While secondary throttle **28** may be controlled in any desired manner, in the aforenoted McDuffie fuel metering system with which the present invention has been illustrated it is controlled by a servo mechanism **42**. Servo **42** includes a casing **43** peripherally supporting a diaphragm **44** having a control rod **46** centrally connected thereto and articulated at its other end to a throttle valve lever **48**. A spring **50** is disposed within servo casing **43** and normally biases throttle **28** in a closed position as shown. Servo chamber **52** communicates with a conduit **54** which is adapted to be supplied with a vacuum force through a throttle controlled switching mechanism **56**.

Mechanism **56** includes a casing **58** peripherally supporting a diaphragm **60**. A valve member **62** is fixed to diaphragm **60** and is adapted to control the admission of vacuum from a supply conduit **64** to conduit **54**. Vacuum from conduit **64** is exposed to both sides of diaphragm **60**, the upper side being supplied by a restricted passage **66**. Due to the greater effective area on the upper side of the diaphragm, valve **62** is maintained in a closed position. The upper diaphragm chamber **68**, defined by diaphragm **60** and cover **70**, is adapted to be vented to the atmosphere through a port **72** controlled by a primary throttle actuated lever **74** and valve **76**. Thus, when the primary throttle **20** is opened beyond a predetermined amount, an eccentric lever **78** coupled to throttle **20** will rotate lever **74** in a clockwise direction raising valve **76** through tension spring **80** and venting chamber **68** to the atmosphere. As a consequence, the pressure differential acting on diaphragm **60** will open valve **62** admitting the vacuum to servo **42** to snap open secondary throttle **28**.

As described in the aforenoted McDuffie application, the fuel metering mechanism **26** includes a pair of diaphragms **82** and **84**, respectively, peripherally clamped between a central casing **86** and end casings **88** and **90**. A U-shaped yoke member **92** pivotally mounted within casing **86** includes an arm **94** fixed to diaphragm **82** and an arm **96** fixed to diaphragm **84**. Diaphragm **82** coacts with casing **88** to form a chamber **98** supplied with venturi vacuum by conduit **24**. Chamber **100** defined by diaphragm **82** and casing **86** is vented to the atmosphere through a port **102**. Thus, the position of the diaphragm **82** is varied in accordance with the vacuum force extant in piezometer ring **22**.

As best seen in Figure 1*b*, yoke **92** includes a partially hollow cross member **97** which coacts with a member **99** having a ball section **101** at one end. The other end of member **99** has a ball section **103** coacting with a supporting arm **105** extending from casing **86**. Member **99** permits pivotal movement of yoke member **92** while at the same time restraining the latter against lateral displacement relative to casing **86**.

Yoke arm **96** includes a metering valve **104** fixed to its free end for movement therewith. Metering valve **104** is described in detail in copending application Serial No. 726,188 Scoville.

Fuel under substantially constant pressure is supplied from a reservoir or tank **106** by a pump **108** to conduit

110. Conduit 110 supplies the constant pressure fuel to a passage 112 in casing 90 of metering mechanism 26.

Diaphragm 84 respectively coacts with casings 86 and 90 to define fuel chambers 114 and 116. Fuel is supplied to chamber 114 in accordance with the position of valve member 104 which in turn is controlled by yoke member 92. Fuel chamber 114 includes an outlet conduit 118 through which an orificed passage 120 supplies fuel to diaphragm chamber 116 and distributor supply passage 122. By thus connecting fuel chambers 114 and 116 through an orificed passage 120, a fuel pressure differential is created across the diaphragm 84 which is proportional to fuel flow and which in turn modifies the position of the yoke member 92 in accordance therewith. Thus, the quantity of metered fuel supplied to conduit 122 is proportional to mass air flow as modified by fuel flow.

The metered fuel from conduit 122 is supplied through branch passages 124 and 126 to a fuel distributing mechanism indicated generally at 130. Fuel distributor 130 comprises a rotary distributor member 132 disposed in casing 134 and adapted to be driven by a shaft 136 in proportion to engine speed. Rotary distributor 132 includes a cylindrical opening 138 within which a shuttle piston 140 is slidably mounted. Casings 142 and 144 coact with casing 134 to define fuel cavities 146 and 148 with distributor opening 138. Cavities 146 and 148 are communicated with fuel passages 150 and 152. Metered fuel from branch passage 124 is supplied to chamber 154 from whence it is delivered to interconnected annular chamber 156 and 158. Rotary distributor passage 152 is adapted to communicate with annular chamber 156 while rotary distributor passage 150 is adapted to communicate through passage 160 with annular chamber 158.

As distributor 132 is rotated, metered fuel under pressure will alternately be supplied to the respective distributor cavities 146 and 148. At the time fuel is being supplied to one of said cavities the pressure of said fuel causes the shuttle piston 140 to be shifted to pump a metered charge of fuel from the other cavity to the appropriate nozzle supply conduit 162. The amount of travel of shuttle piston 140 and hence the quantity of the timed fuel charge is determined by the distance between a fixed stop 164 and an adjustable stop 166.

With the parts in the position shown in Figure 1*a*, fuel under pressure is supplied from annular chamber 154 to distributor passage 152 and cavity 148 forcing shuttle piston 140 to the left where the fuel in cavity 146 is forced out through distributor passage 150 where it flows through passage 168 to conduit 162. As the distributor 132 is rotated this process is reversed and the shuttle piston moved in the opposite direction to supply fuel to another fuel nozzle from cavity 148.

The adjustable shuttle piston stop 166 is slidably mounted in casing opening 170 and projects within a chamber 172 formed in casing 174 and enclosed at one end by a diaphragm member 176. Metered fuel under pressure is supplied to chamber 172 by branch passage 126.

A cam member 178 is centrally fixed to diaphragm plug 180. Cam member 178 is adapted to coact with a follower member 182 mounted on adjustable stop 166. The fuel pressure in chamber 172 acts upon diaphragm 176 in opposition to the substantially constant force of the fuel pressure acting on diaphragm 183 in casing chamber 184 which is supplied by conduit 186. Thus, as the quantity and pressure of fuel supplied by the metering mechanism 26 is increased with mass air flow, cam 178 is moved to the left whereby adjustable stop 166 is similarly so moved by the pressure of fuel in cavity 146 thereby increasing the quantity of fuel discharged by shuttle piston 140 during each reciprocation thereof reflecting the increased need of the engine for fuel.

The unit fuel pressure in chamber 184 is greater than that in chamber 172, therefore, it is necessary that the effective area of diaphragm 183 be sufficiently less than that of diaphragm 176 to insure under all air flow conditions the force acting on the latter diaphragm determines the position of cam 178. By utilizing fuel pressure on the input side of metering mechanism 26 to oppose metered fuel pressure, it is assured only pressure changes due in mass air flow will affect the position of cam 178.

I claim:

1. A charge forming device for an internal combustion engine comprising an air induction passage, throttle means for controlling the flow of air through said induction passage, venturi means in said induction passage, a plurality of intake passages adapted to communicate said induction passage with the individual cylinders of the engine, a fuel nozzle in each of said intake passages, a source of fuel under pressure, a fuel metering valve, means responsive to the mass of air flow through said venturi means for controlling said metering valve, and a fuel distributor intermediate said metering valve and said nozzles for fuel charges to said nozzles in timed relation to engine speed, said distributor including means responsive to the metered fuel pressure for varying the magnitude of said fuel charges.

2. A charge forming device for an internal combustion engine comprising an air induction passage, throttle means for controlling the flow of air through said induction passage, venturi means in said induction passage, a plurality of intake passages adapted to communicate said induction passage with the individual cylinders of the engine, a fuel nozzle in each of said intake passages, a source of fuel under pressure, a fuel metering valve, means responsive to the mass of air flow through said venturi means for controlling said metering valve, and a fuel distributor intermediate said metering valve and said nozzles for distributing fuel to said nozzles in timed relation to engine speed, said fuel distributor comprising a rotary distributor member driven in timed relation to engine speed, a shuttle piston member reciprocably mounted in said member, a fixed stop and an adjustable stop for controlling the reciprocable movement of said piston, fuel cavities defined by the respective ends of said piston and said rotary distributor member, passage means for alternately communicating said fuel cavities with said metering valve and said fuel nozzles whereby reciprocation of said piston will supply a timed quantity of fuel to each nozzle, a chamber, passage means communicating said metering valve with said chamber, said adjustable stop including an end projecting within said chamber, cam means in said chamber adapted to coact with said end of said adjustable stop to vary the axial position thereof, and diaphragm means in said chamber operatively connected to said cam and adapted to vary the position thereof in accordance with the quantity of fuel supplied by said metering valve.

3. A charge forming device for an internal combustion engine comprising an air induction passage, throttle means for controlling the flow of air through said induction passage, venturi means in said induction passage, a plurality of intake passages adapted to communicate said induction passage with the individual cylinders of the engine, a fuel nozzle in each of said intake passages, a source of fuel under pressure, a fuel metering valve, means responsive to the mass of air flow through said venturi means for controlling said metering valve, and a fuel distributor intermediate said metering valve and said nozzles for distributing fuel to said nozzles in timed relation to engine speed, said fuel distributor comprising a rotary distributor member driven in timed relation to engine speed, a shuttle piston member reciprocably mounted in said member, a fixed stop and an adjustable stop for controlling the reciprocable movement of said piston, fuel cavities defined by the respective ends of said piston and said rotary distributor member, passage means for alternately communicating said fuel cavities with said metering valve and said fuel nozzles whereby reciprocation of said piston will supply a timed quantity of fuel

to each nozzle, a chamber, passage means communicating said metering valve with said chamber, said adjustable stop including an end projecting within said chamber, cam means in said chamber adapted to coact with said end of said adjustable stop to vary the axial position thereof, and means in said chamber operatively connected to said cam and adapted to vary the position thereof in accordance with the quantity of fuel supplied by said metering valve.

4. A charge forming device for an internal combustion engine comprising an air induction passage, throttle means for controlling the flow of air through said induction passage, venturi means in said induction passage, a plurality of intake passages adapted to communicate said induction passage with the individual cylinders of the engine, a fuel nozzle in each of said intake passages, a source of fuel under pressure, a fuel metering valve, means responsive to the mass of air flow through said venturi means for controlling said metering valve, and a fuel distributor intermediate said metering valve and said nozzles for distributing fuel to said nozzles in timed relation to engine speed, said fuel distributor comprising a rotary distributor member driven in timed relation to engine speed, a shuttle piston member reciprocably mounted in said member, a fixed stop and an adjustable stop for controlling the reciprocable movement of said piston, fuel cavities defined by the respective ends of said piston and said rotary distributor member, passage means for alternately communicating said fuel cavities with said metering valve and said fuel nozzles whereby reciprocation of said piston will supply a timed quantity of fuel to each nozzle, a chamber, passage means communicating said metering valve with said chamber, said adjustable stop including an end projecting within said chamber, cam means in said chamber adapted to coact with said end of said adjustable stop to vary the axial position thereof, and diaphragm means responsive to the metered fuel pressure for varying the position of said cam relative to the adjustable stop.

5. A charge forming device for an internal combustion engine comprising an air induction passage, throttle

means for controlling the flow of air through said induction passage, venturi means in said induction passage, a plurality of intake passages adapted to communicate said induction passage with the individual cylinders of the engine, a fuel nozzle in each of said intake passages, a source of fuel under pressure, a fuel metering valve, means responsive to the mass of air flow through said venturi means for controlling said metering valve, and a fuel distributor intermediate said metering valve and said nozzles for distributing fuel to said nozzles in timed relation to engine speed, said fuel distributor comprising a rotary distributor member driven in timed relation to engine speed, a shuttle piston member reciprococably mounted in said member, a fixed stop and an adjustable stop for controlling the reciprocable movement of said piston, fuel cavities defined by the respective ends of said piston and said rotary distributor member, passage means for alternately communicating said fuel cavities with said metering valve and said fuel nozzles whereby reciprocation of said piston will supply a timed quantity of fuel to each nozzle, a chamber, passage means communicating said metering valve with said chamber, said adjustable stop including an end projecting within said chamber, cam means in said chamber adapted to coact with said end of said adjustable stop to vary the axial position thereof, first diaphragm means in said chamber operatively connected to said cam and adapted to vary the position thereof in accordance with metered fuel pressure, second diaphragm means operatively connected to said cam, and conduit means communicating said source of fuel under pressure with said second diaphragm to oppose the force of the metered fuel pressure.

6. A charge forming device as set forth in claim 5 in which the area of said second diaphragm means is less than that of the first diaphragm means.

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