

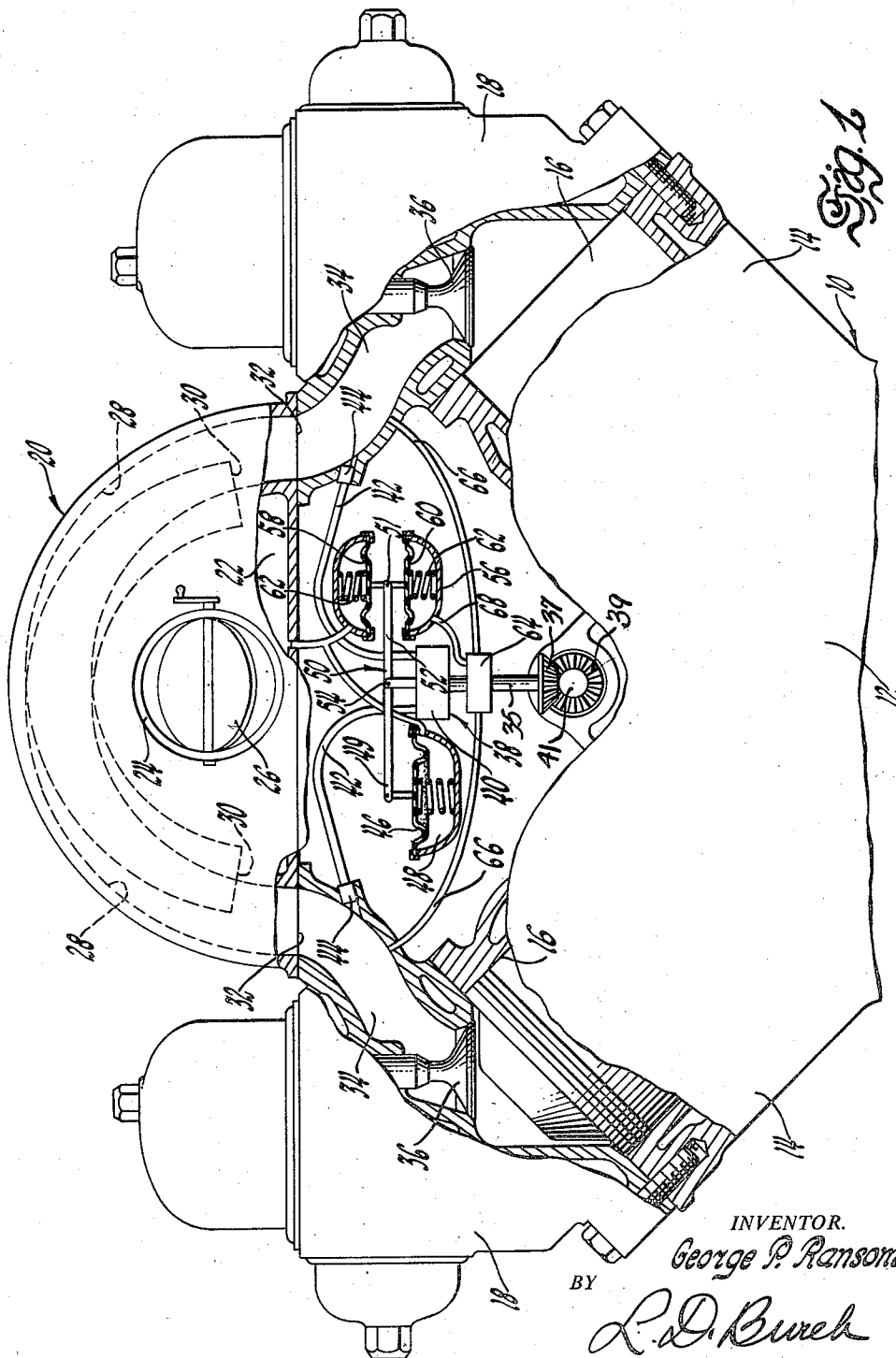
June 3, 1958

G. P. RANSOM
FUEL INJECTION SYSTEM

2,837,074

Filed Sept. 10, 1956

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

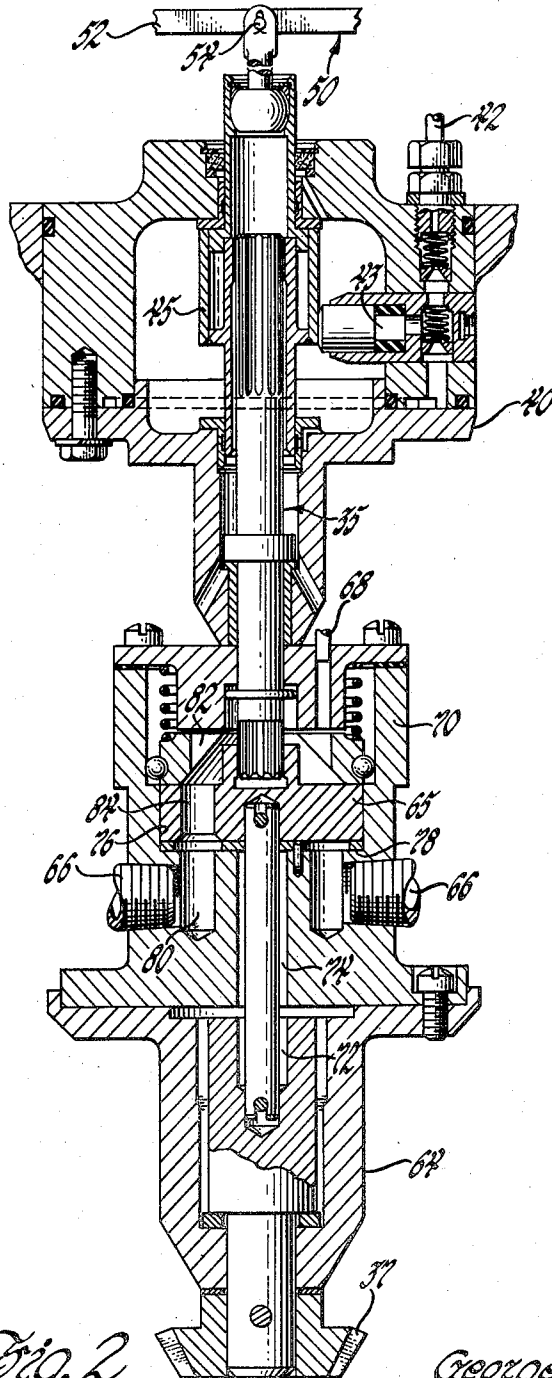


Fig. 2

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2,837,074

FUEL INJECTION SYSTEM

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Application September 10, 1956, Serial No. 608,850

11 Claims. (Cl. 123—140)

The present invention relates to internal combustion engines and more particularly to the charge forming means therefor.

In an internal combustion engine of the so-called spark ignited variety the charge for the cylinders comprises a combustible mixture of air and fuel which is compressed and ignited in the engine cylinders. A considerable amount of effort has been directed toward devising a satisfactory fuel injection system which is capable of injecting metered quantities of fuel directly into the charges in some predetermined proportion to the volume of air flowing into the engine. In one form of fuel injection system, namely, the so-called speed density type, fuel pumping means are provided that are driven by the engine and have an output proportional to the speed of the engine in combination with a metering mechanism responsive to the density of the charge entering the cylinders and effective to modify the output of the pump in proportion to the density. Normally, the metering mechanism measures the density of the charge by sensing the amount of vacuum in the induction system. In other words an injector pump is driven by the engine to have an output proportional to the speed thereof and means responsive to the induction vacuum meters the output of the pump in proportion thereto. Such a system will provide a charge having a substantially constant air-fuel ratio over most of the normal operating range of the engine. However, if there is a change in the volumetric efficiency of the induction system due to high speed operation of the engine or for any other reason, the induction vacuum may not reflect this change and, accordingly, may not be a sufficiently accurate index of the density of the charge delivered to the cylinders. This problem is particularly acute when the induction system includes an enlarged plenum chamber and a plurality of induction passages that are tuned to resonate during one or more engine operating conditions. The induction vacuum in the plenum chamber may be an inaccurate metering signal during periods of resonance.

It is now proposed to provide a so-called speed density type of fuel injection system for an internal combustion engine which is particularly adapted to accurately meter the fuel flow in proportion to the air flow by sensing the amount of vacuum present in the induction system. More particularly this is to be accomplished by providing a metering mechanism responsive to the induction vacuum for varying the output of an injector pump in proportion thereto. In order to compensate for any changes that may occur in the volumetric efficiency of the induction system, additional means are provided to sense the effects of the flow through the induction passages and to adjust the action of the metering mechanism in accordance therewith. This means includes a pressure responsive device that is adapted to sense the pressure difference between the induction vacuum anterior to the duction passages and the air pressure in the induction passages at the end thereof adjacent the intake valves. This pressure difference

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will reflect the changes in volumetric efficiency and will adjust the metering means to compensate therefor.

In the drawing:

This figure is an end view with the portions thereof being broken away of an internal combustion engine employing a fuel injection system embodying the present invention.

Referring to the drawing in more detail the present invention is particularly adapted for use on an internal combustion engine 10 of the so-called V-type wherein a cylinder block 12 includes a pair of angularly disposed banks 14 of cylinders 16. Separate cylinder heads 18 are secured to each of these banks 14 to close the upper ends of the cylinders 16 and thereby form combustion chambers.

In order to charge the cylinders 16 with a supply of air an induction system 20 may be provided in the space between the two banks 14. This induction system 20 includes a housing forming an enlarged plenum chamber 22 and having an inlet 24 thereto with a throttle valve 26 therein to control the volume of the charge. A plurality of induction passages 28 are provided that have the inlet ends 30 thereof opening into the plenum chamber 22 and the outlet ends thereof registering with the inlet ports 32 formed by the intake passages 34 in the cylinder heads 18.

The intake passages 34 communicate with the cylinders 16 while the intake valves 36 which are actuated by the engine camshaft control the timing of the flow there-through. Incidentally, it has been found highly desirable to tune the induction and intake passages 28 and 34 to resonate during one or more engine operating conditions such as disclosed and claimed in copending application Serial No. 608,935 Dolza, filed September 10, 1956, Fuel Injection System. It is sufficient for present purposes to note that the combined length of each intake or induction pipe 28 and induction passage 34 will determine the engine's speed at which the air charge flowing through will resonate and hence give a supercharged effect to the inducted air. Further, for convenience as well as good air flow characteristics the intake pipes 28 are formed of a gently curving shape.

In order to form a combustible charge of air and fuel, a fuel injection system 38 may be provided for injecting metered quantities of fuel into the charges as they flow through the induction system 20. In the present instance the injection system 38 comprises a pump 40 which is driven from a composite shaft 35 connected through beveled gears 37 and 39 to the engine camshaft 41. The pump 40 will thus operate in timed relation with the speed of the engine 10 and will discharge fuel therefrom in proportion to the speed. Although this pump 40 may be of any desired variety, it has been found desirable to employ a pump having a separate pumping cell 43 for each cylinder which is driven by a variable lift cam 45; for example, such as disclosed and claimed in copending application Serial No. 512,448, Fuel Injection System invented by John Dolza and filed on June 1, 1955. Each of these cells 43 has an injector line 42 with a suitable nozzle 44 on the end thereof for spraying metered fuel into the charges in the induction passages 28. It, of course, should be understood that any suitable pump 40 may be provided and the fuel discharged therefrom distributed to the cylinders 16 by any suitable distribution system. In order to vary the output of fuel discharged from the pump 40 in proportion to the fuel demands of the engine 10, a diaphragm 46 may be provided which forms a diaphragm chamber 48 that is connected with the plenum chamber 22. The diaphragm 46 is interconnected with one end 49 of a walking beam 50. The opposite end 52 of the beam 50 is supported by an adjustable fulcrum 51. The center 54 of this beam 50 is interconnected with the variable lift cam in the pump 40 for moving the

cam axially in response to the induction vacuum. It may thus be seen that since the diaphragm 46 will sense the density of the air and move the beam 50 to adjust the pump 40 to discharge fuel in proportion thereto, a metered quantity of fuel will be delivered to the engine cylinders 16.

However, since there may be variations in the volumetric efficiency of the induction system 20, particularly during a resonant flow in the induction passages 28, a trimmer adjusting means 56 may be provided on the opposite end of the walking beam to position the adjustable fulcrum 51. This trimmer adjusting means 56 may be responsive to the difference between the air pressure in the plenum chamber 22 and the pressures in the induction passages 28 immediately adjacent to the intake valves 36. In the present instance this means 56 includes a first diaphragm 58 responsive to induction vacuum and a diaphragm 60 responsive to the air pressure adjacent the intake valves 36. These diaphragms 58 and 60 are interconnected with the end 52 of the walking beam 50 and together with the springs 62 position this end 52 as a function of this pressure difference. In order to obtain a pressure signal indicative of the pressures of the charge adjacent the intake valves 36, a sampling valve 64 such as disclosed and claimed in copending application Serial No. 594,730 Dolza, filed June 29, 1956, may be provided. This sampling valve 64 includes a rotary plate 65 also driven by composite shaft 35 from the engine camshaft to sequentially interconnect each of the sampling tubes 66 with the signal tube 63 connected to the chamber for diaphragm 60. This interconnection is preferably made during some particular portion of the cycle of operation of the individual cylinders. As a result a composite signal will be transmitted through the signal tube 63 to the diaphragm chamber.

The sampling valve 64 comprises a stationary housing 70 having a passage 72 extending axially therethrough with portions 74 and 76 of different diameters and separated by a shoulder 78. A plurality of sampling chambers 80 adapted to be interconnected with the intake passages 66 are disposed around said axial passage. The sampling chambers 80 form a series of circumferentially spaced openings in shoulder 78. The throttle 63 has one side thereof supported by shoulder 78 and is driven by the engine through composite shaft 35 in timed relation to the operation thereof. A pressure chamber 82 is disposed on the opposite side of said throttle and is operatively interconnected with a control unit 56 of the injection system. The rotor 65 includes a passage 84 for intermittently interconnecting said sampling chambers 80 with the pressure chamber 82 producing a resultant signal therein proportional to the flow through the intake passages 34 and effective to actuate the control unit 56 accordingly.

By properly proportioning the diaphragms 46, 58 and 60 and springs 62, it will be possible for these diaphragms to compensate for any changes in the volumetric efficiency which will not otherwise be reflected in the induction vacuum.

I claim:

1. A fuel injection system for an internal combustion engine having a plurality of cylinders and an induction system with induction passages for charging said cylinders, said injection system comprising pumping means for injecting metered quantities of fuel into the charges in said induction passages, metering means responsive to the vacuum in said induction system operatively interconnected with said pumping means and effective to meter said injected fuel in proportion to said vacuum, and means responsive to the difference in the pressures at the opposite ends of said induction passages to modify the action of said metering means in proportion to said difference.

2. A fuel injection system for an internal combustion engine having a plurality of cylinders and an induction

system with induction passages for charging said cylinders, said injection system comprising a fuel pump driven by said engine and discharging fuel therefrom in proportion to the speed thereof for injecting metered quantities of fuel into the charges in said induction passages, metering means responsive to the vacuum in said induction system operatively interconnected with said pumping means and effective to meter said injected fuel in proportion to said vacuum, sampling means adapted to sense the pressures in said induction passages adjacent said cylinders to form a composite signal proportional to said pressures and means responsive to the difference between said composite signal and said vacuum to modify the metering action of said metering means in proportion to said difference.

3. In an internal combustion engine having a plurality of cylinders, an induction system having a plurality of induction passages for charging said cylinders, said passages being tuned to resonate during at least one engine operating condition to tend to supercharge said cylinders, pumping means for injecting metered quantities of fuel into the charges in said induction passages, metering means responsive to the vacuum in said induction system and effective to meter said injected fuel in proportion thereto, compensating means operatively interconnected with said metering means and responsive to the difference in the pressures at the opposite ends of said induction passages for modifying the action of said metering means in proportion to said difference.

4. In an internal combustion engine having a plurality of cylinders, an induction system having a plurality of induction passages for charging said cylinders, said passages being substantially identical and tuned to resonate during at least one engine operating condition to tend to supercharge said cylinders, a fuel pump driven by said engine for discharging fuel therefrom in proportion to said speed for injecting metered quantities of fuel into the charges in said induction passages, metering means operatively interconnected with said pump and responsive to the vacuum in said induction system and effective to meter said injected fuel in proportion thereto, sampling means adapted to sense the pressures in said induction passages adjacent said cylinders to form a composite signal proportional thereto, compensating means operatively interconnected with said metering means and responsive to the difference between said vacuum and said composite signal for modifying the metering action of said metering means in proportion to said difference.

5. In an internal combustion engine having a plurality of cylinders, an induction system with a plenum chamber and a plurality of induction passages interconnecting said plenum chamber with said cylinders for charging them with a combustible charge of air and fuel, said induction passages being adapted to resonate during one or more engine operating conditions, a pump driven by said engine and discharging fuel therefrom in proportion to the speed thereof for injecting fuel into the charges for said cylinders, metering means responsive to the vacuum in said plenum chamber for metering said injected fuel in proportion to said vacuum, compensating means responsive to the difference in the pressures at the opposite ends of said induction passages for modifying the metering action of said metering means.

6. In an internal combustion engine having a plurality of cylinders, an induction system with a plenum chamber and a plurality of induction passages interconnecting said plenum chamber with said cylinders for charging them, said induction passages being adapted to resonate during one or more engine operating conditions, a fuel pump driven by said engine and having an output proportional to the speed thereof and adapted to inject metered quantities of fuel into the charges for said cylinders, metering means responsive to the vacuum in said plenum chamber and operatively interconnected with said fuel pump for metering said injected fuel in proportion

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thereto, a sampling valve adapted to sense the pressures in said induction passages adjacent said cylinders to form a composite signal proportional thereto, compensating means responsive to the difference between said composite signal and the pressure in said plenum chamber for modifying the metering action of said metering means in response thereto.

7. A fuel injection system for an internal combustion engine having a plurality of cylinders and an induction system with induction passages for charging said cylinders, said injection system comprising a fuel pump driven by said engine for discharging fuel therefrom in proportion to the speed of said engine for injecting fuel into the charges in said induction passages, metering means operatively interconnected with said pump and effective to meter the volume of said injected fuel, a pressure sensitive device responsive to the vacuum in said induction system and operatively interconnected with said metering means by a walking beam for actuating said metering means in proportion to said vacuum, means responsive to the difference in the pressures at the opposite ends of said induction passages operatively interconnected with said walking beam to modify the metering action of said metering means in proportion to said difference.

8. In an internal combustion engine having a plurality of cylinders, an induction system having a plenum chamber and a plurality of induction passages interconnecting said plenum chamber with said cylinders for charging them, said induction passages being adapted to resonate during one or more engine operating conditions, a fuel pump driven by said engine and having an output proportional to the speed thereof and adapted to inject metered fuel into the charges for said cylinders, metering means operatively interconnected with said fuel pump for metering said injected fuel, a walking beam operatively interconnected with said metering means for controlling the same, a pressure sensitive device responsive to the vacuum in said plenum chamber and operatively interconnected with said beam for actuating the said metering means to meter the output of said fuel pump in proportion thereto, compensating means responsive to the difference in the pressures at the opposite ends of said induction passages and being connected to said beam for modifying the metering action of said metering means proportional to said difference.

9. In an internal combustion engine having a plurality of cylinders, an induction system having a plenum chamber and a plurality of induction passages interconnecting said plenum chamber with said cylinders for charging them, said induction passages being adapted to resonate during one or more engine operating conditions, a fuel pump driven by said engine and having an output proportional to the speed thereof and adapted to inject metered fuel into the charges for said cylinders, metering means operatively interconnected with said fuel pump for metering said injected fuel, a walking beam operatively interconnected with said metering means for controlling the same, a pressure sensitive device responsive to the vacuum in said plenum chamber and operatively interconnected with said metering means for actuating said means to meter the output of said fuel pump in proportion thereto, a sampling valve driven in timed relation

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to said engine for sequentially sensing the pressures in the ends of said induction passages adjacent said cylinders to form a composite signal proportional to said pressures, compensating means responsive to the difference between said composite signal and said vacuum and being connected to said beam for modifying the metering action of said metering means proportional to said difference.

10. In an internal combustion engine having a plurality of cylinders, an induction system having a plenum chamber and a plurality of induction passages interconnecting said plenum chamber with said cylinders for charging them, said induction passages being adapted to resonate during one or more engine operating conditions, a fuel pump driven by said engine and having an output proportional to the speed thereof and adapted to inject metered fuel into the charges for said cylinders, metering means operatively interconnected with said fuel pump for metering said injected fuel, a walking beam having the center thereof operatively interconnected with said metering means for controlling the same, a pressure sensitive device responsive to the vacuum in said plenum chamber and operatively interconnected with one end of said beam for actuating said metering means to meter the output of said fuel pump in proportion thereto, a pair of pressure sensitive devices connected to the opposite end of said beam for modifying the metering action of said metering means, one of said devices being responsive to the pressures in said induction passages adjacent said cylinders and the other of said devices being responsive to the pressure in said plenum chamber.

11. In an internal combustion engine having a plurality of cylinders, an induction system having a plenum chamber and a plurality of induction passages interconnecting said plenum chamber with said cylinders for charging them, said induction passages being adapted to resonate during one or more engine operating conditions, a fuel pump driven by said engine and having an output proportional to the speed thereof and adapted to inject metered fuel into the charges for said cylinders, metering means operatively interconnected with said fuel pump for metering said injected fuel, a walking beam having the center thereof operatively interconnected with said metering means for controlling the same, a pressure sensitive device responsive to the vacuum in said plenum chamber and operatively interconnected with one end of said beam for actuating said metering means to meter the output of said fuel pump in proportion thereto, a sampling valve driven in timed relation to said engine for sequentially sampling the pressures in said induction passages adjacent said cylinders to form a composite signal, a pair of pressure sensitive devices connected to the opposite end of said walking beam for modifying the metering action of said metering means, one of said pressure sensitive devices being responsive to said composite signal and the other of said devices being responsive to said vacuum.

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