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Aquino et al.

[11] **3,903,859**

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[54] **SUPPLEMENTAL FUEL SYSTEM FOR EXHAUST GAS RECIRCULATING SYSTEM**

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[73] Assignee: **Ford Motor Company**, Dearborn, Mich.

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[52] **U.S. Cl.** ..... **123/119 A**

[51] **Int. Cl.²** **F02M 25/06**

[58] **Field of Search** ..... 123/119 A

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Assistant Examiner—David D. Reynolds
Attorney, Agent, or Firm—Robert E. McCollum; Keith L. Zerschling

[57] **ABSTRACT**

A carburetor is supplied with an additional fuel and air channel connected to the engine intake manifold past a movable valve that opens the channel only when exhaust gases are being recirculated into the engine so that engine driveability is improved. The valve is sensitive to the movement of a second valve controlling the recirculation of the exhaust gases as a function of throttle valve movement.

9 Claims, 4 Drawing Figures

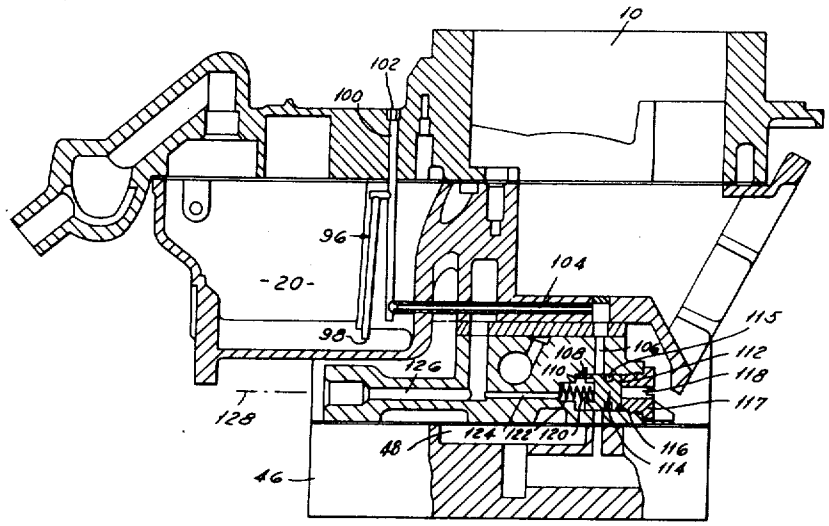


FIG.1

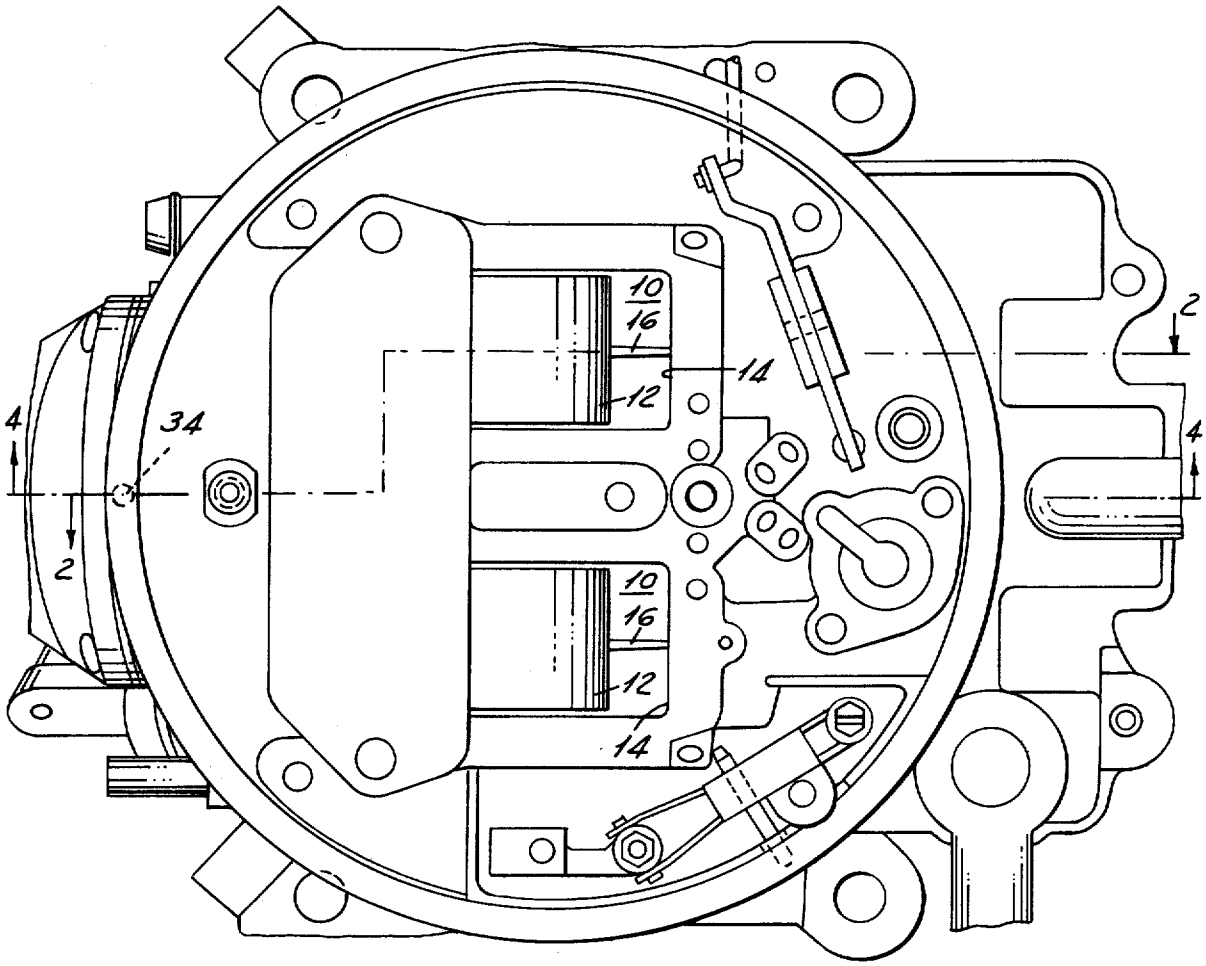


FIG. 2

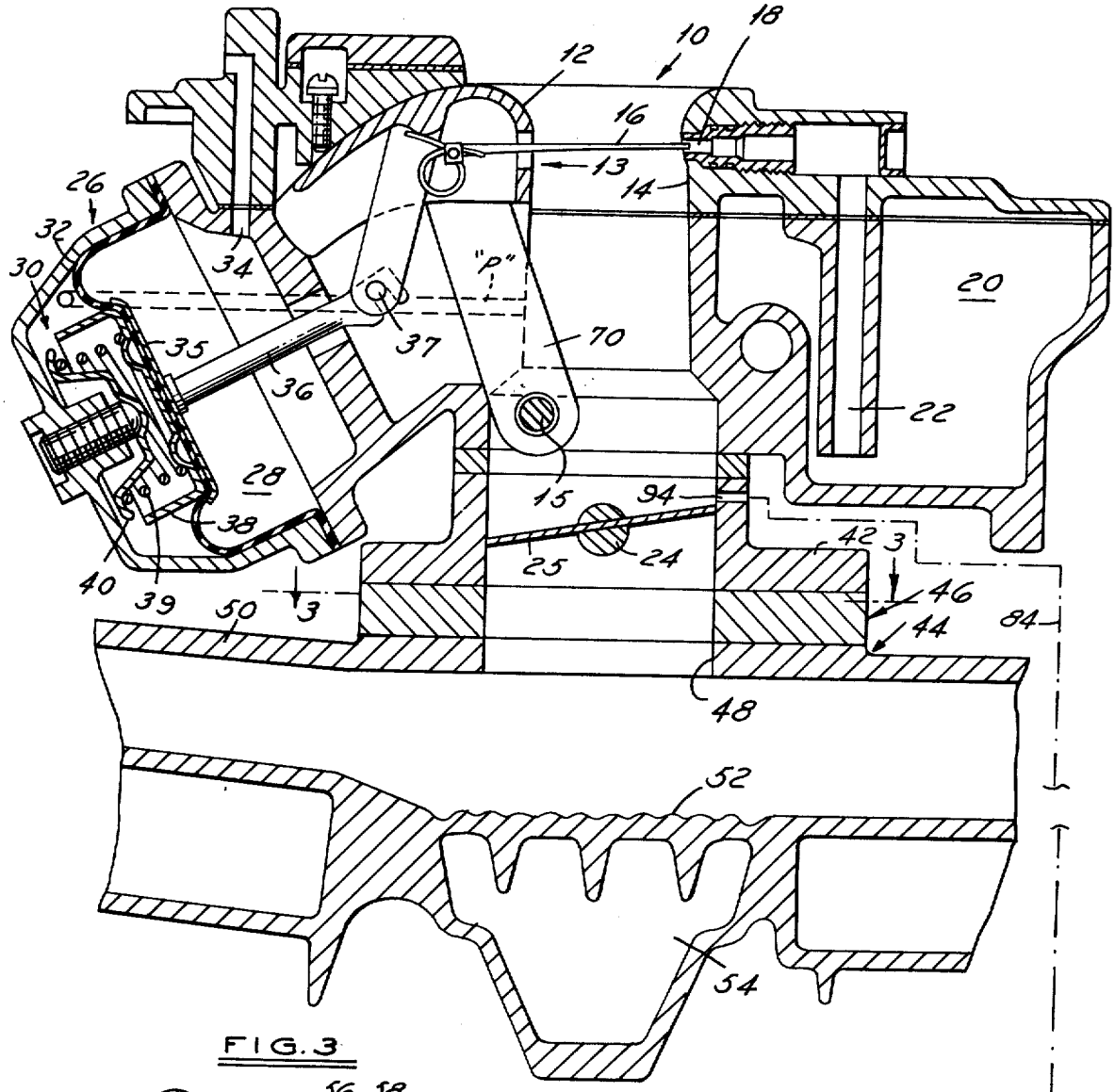

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FIG. 3

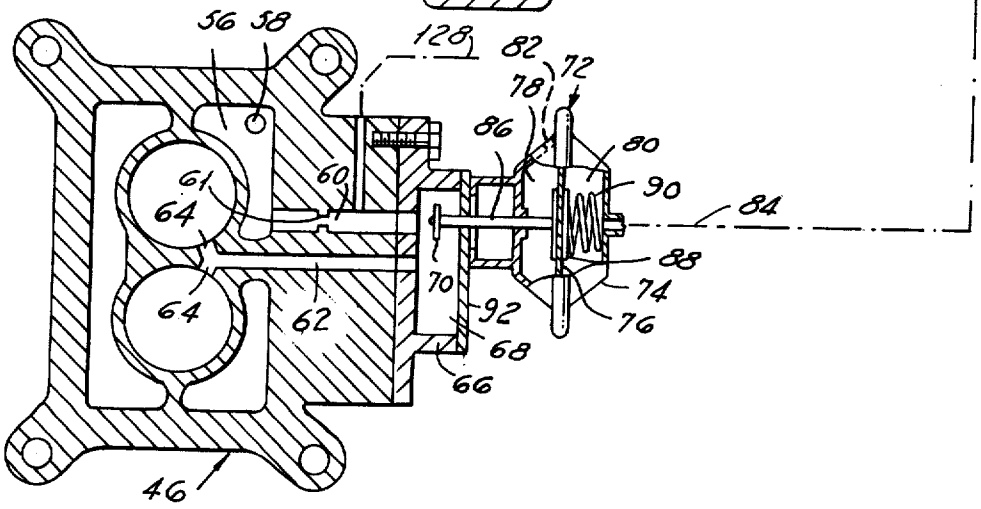
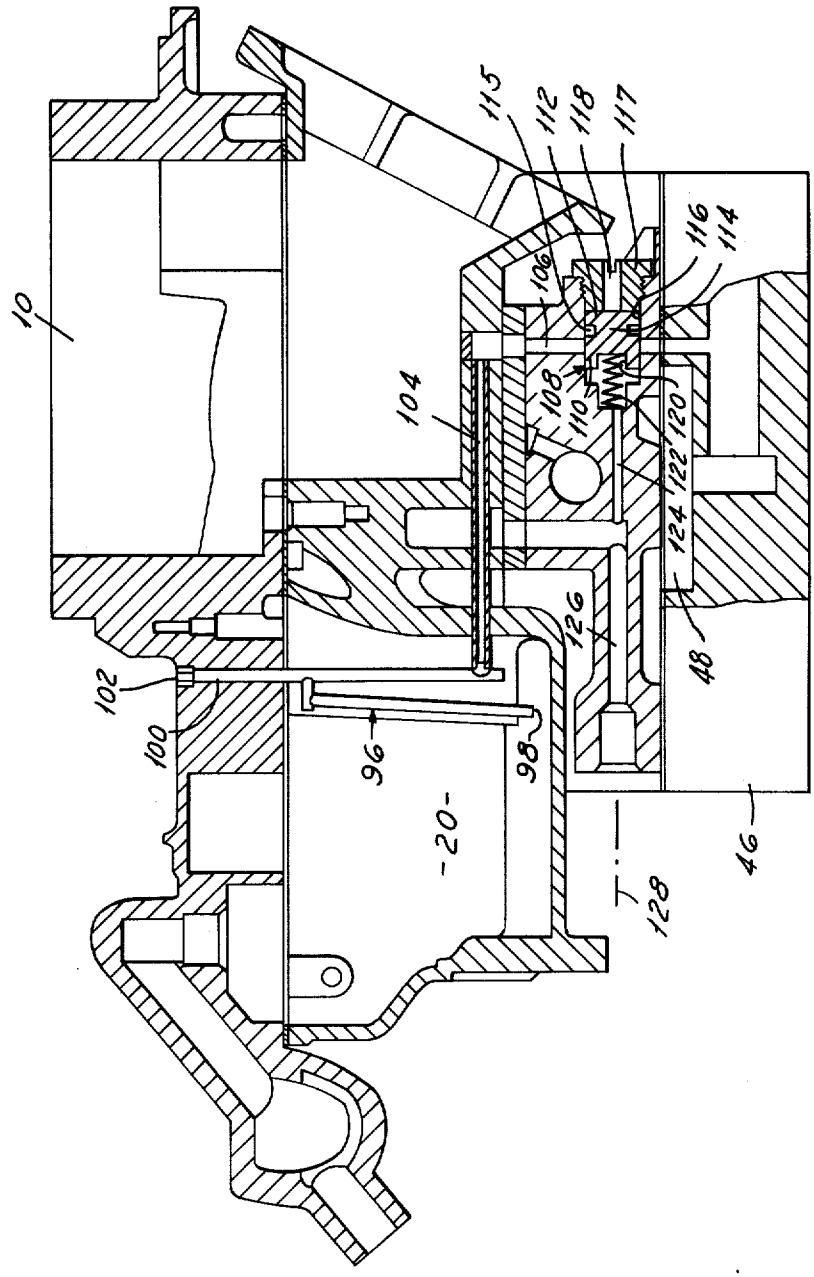

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FIG. 4


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SUPPLEMENTAL FUEL SYSTEM FOR EXHAUST GAS RECIRCULATING SYSTEM

This invention relates in general to an internal combustion engine exhaust gas recirculating system. More particularly, it relates to one in which a small amount of additional fuel is added to the intake manifold during the recirculation of exhaust gases.

The practice of recirculating exhaust gases into the engine to reduce combustion peak temperatures and pressures and thereby reduce the output of NO_x is a well known expedient. However, such recirculation of exhaust gases usually results in reducing engine driveability to a less than satisfactory level, especially during light acceleration modes of operation when the flow rate of recirculated gases is higher. Most exhaust gas recirculating systems have no provision for compensating for a decrease in driveability other than to make adjustments to other parts of the engine not associated with the exhaust gas flow.

It is a primary object of this invention to add a small amount of fuel to the exhaust gases as they are recirculated into the engine, to improve engine driveability without increasing the level of emission of undesirable elements.

It is a further object of the invention to provide an engine exhaust gas recirculating system that includes a passage between the engine exhaust gas crossover passage that passes beneath the carburetor throttle bores to vaporize the air/fuel mixture, and the engine intake manifold, the passage containing a valve that is controlled in general as a function of changes in engine operating modes whereby opening of the valve triggers a supplemental fuel supply to add a small amount of fuel to the intake manifold in proportion to the flow of exhaust gases, to improve engine driveability.

Other objects, features and advantages of the invention will become more apparent upon reference to the succeeding detailed description thereof, and to the drawings illustrating the preferred embodiment thereof; wherein,

FIG. 1 is a plan view of a portion of a downdraft type carburetor embodying the invention;

FIG. 2 is a cross-sectional view taken on a plane indicated by and viewed in the direction of the arrows 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view, on a reduced scale, taken on a plane indicated by and viewed in the direction of the arrows 3—3 of FIG. 2; and,

FIG. 4 is a cross-sectional view taken on a plane indicated by and viewed in the direction of the arrows 4—4 of FIG. 1.

FIG. 1, which is essentially to scale, is a plan view of a variable area venturi carburetor of the downdraft type. It has a pair of rectangularly shaped induction passages 10, each having one end wall 12 which is pivotally movable and has the profile (FIG. 2) of one-half of a venturi 13. Each opposite fixed cooperating wall 14 is formed with the mating profile of a portion of a venturi. The airflow capacity, therefore, varies in proportion to the opening movement of walls 12 of the induction passages.

As seen more clearly in FIG. 2, movable walls 12 are pivotally mounted at 15 on a stationary pin. Pivotally attached to each of the wall bodies is a fuel metering rod or needle 16 that is tapered for cooperation with a main fuel metering jet 18. The needles have a controlled taper to provide a richer air/fuel mixture at the lower and higher ends of the venturi range. Each jet is located in an aperture inside wall 14 at approximately the throat or most constricted section of venturi 13. A fuel float bowl or reservoir 20 has a pair of identical passages 22 (only one shown) conducting fuel to the main metering jets 18. Downstream of the venturis, the carburetor throttle body portion rotatably mounts a shaft 24 on which are fixed a pair (only one shown) of conventional throttle plates 25 that control the flow of air and fuel through induction passages 10.

The size of venturis 13 and the movement of walls 12 is controlled in this case by a spring returned, control vacuum actuated, diaphragm type servo 26. The servo consists of a hollow two-piece casting divided into two chambers 28 and 30 by an annular flexible diaphragm 32. The diaphragm is sealingly mounted along its edge in the casting. Chamber 28 is an air chamber, connected to ambient or atmospheric pressure through a passage 34. Chamber 30 is a vacuum chamber connected to induction passages 10 by a passage P at a point below the throat but still in the venturi 13. This subjects chamber 30 to changes in a control vacuum that varies with airflow but at a rate that is slightly different than true venturi vacuum. The exact location of the tap of course is a matter of choice.

Fixed to one side of servo diaphragm 32, by a retainer 34, is a plunger or actuator 36. The plunger is pivotally connected to a shaft 37 interconnecting cast portions of the movable walls 12. Fixed to the other side of diaphragm 32 is a retainer 38 against which is seated a spring 39. The other end of the spring bears against a seat 40 axially adjustable to vary the spring preload.

The throttle body 42 is flanged as indicated for bolting to the top of the engine intake manifold 44, with a spacer element 46 located between. Manifold 44 has a number (only one shown) of vertical risers or bores 48 that are aligned for cooperation with the discharge end of the carburetor induction passages 10. The risers 48 open at their lower ends into manifold logs or trunks 50 that extend at right angles to the risers for passage of the mixture to the engine intake valves, not shown.

The floor 52 of the intake manifold in this case is heated in a known manner by exhaust gases passing through an exhaust gas crossover passage 54. The latter passes from the exhaust manifold, not shown, on one side of the engine to the exhaust manifold on the opposite side beneath the intake manifold trunks 50 to provide the usual "hot spot" beneath the carburetor riser bores to better vaporize the air/fuel mixture.

As best seen in FIG. 3, the spacer 46 is provided with a worm-like recess 56 that is connected directly to crossover passage 54 in FIG. 2 by a bore or passage 58. Also connected to recess 56 is a passage 60 containing a flow restricting orifice 61. Passage 60 is alternately blocked or connected to a central bore or passage 62 which communicates with the risers 48 through a pair of ports 64. Mounted to one side of the spacer is a cup shaped boss 66 forming a chamber 68 through which passages 60 and 62 are interconnected.

It is necessary and desirable to provide some sort of control to prevent the recirculation of exhaust gases at undesirable times. For this purpose, passage 60 normally is closed by a valve 70 that is moved to an open position by a servo 72. The servo includes a hollow outer shell 74 containing an annular flexible diaphragm

76. The latter divides the interior into an air chamber 78 and a signal vacuum chamber 80. Chamber 78 is connected to atmospheric pressure through a vent 82, while chamber 80 is connected to a vacuum signal force through a line 84. The stem 86 of valve 70 is fixed to a pair of retainers 88 secured to diaphragm 76. They serve as a seat for a compression spring 90 normally biasing the valve to its closed position. The stem slidably and sealingly projects through a plate 92 closing chamber 68.

As shown in FIG. 2, the carburetor contains an exhaust gas recirculating (EGR) port 94 that is located above the closed position of throttle valve 25 to be traversed by the edge of the throttle valve as it moves open. The pressure in port 94 thereby varies from atmospheric to the manifold vacuum level as a function of the opening of throttle valve 25. Port 94 is connected to passage 84.

As stated initially, it is desirable when the exhaust gases are recirculated that a small amount of additional fuel be added to the exhaust gases for better driveability purposes. The construction shown in FIG. 4 provides for the automatic induction of this fuel. More specifically, float bowl 20 contains an inverted U-shaped fuel passage 96 open at its lower end 98 to the fuel in reservoir 20. At its upper end, the fuel channel is joined to an air bleed passage 100 that opens at its top through a fixed area orifice 102 to the clean air side of the engine air cleaner, not shown. At its alternate lower end, fuel channel 96 is joined to a horizontal passage 104 intersecting a vertical passage 106. Passage 106 is connected to the spacer passage 62 (FIG. 3) past a spool type valve 108. The latter has a pair of spaced lands 110 and 112 interconnected by a neck portion 114 of reduced diameter. The latter defines a channel 115 adapted to register at times with the spaced portions of passage 106 to connect fuel to intake passage 62. The spool valve bore 116 is closed by an adjustably mounted plug 117. The plug has a hollow screw 118 to permit communication of atmospheric pressure against the end face of valve land 112. The opposite valve land 110 has a recess 120 serving as a seat for a spring 122. The spring normally biases the valve rightwardly to block communication of the intake manifold vacuum in passage 62 to act on fuel line 106. The screw 118 acts as a stop to determine the closed position of the valve 108. Another screw, not shown, can be provided to adjust the preload on spring 122.

As seen in FIG. 4, the left end of bore 116 is connected by a pair of passages 124 and 126 to a vacuum signal passage 128 shown in FIG. 3. The latter is connected to vacuum passage 60 at a point between the orifice 61 and valve 70 so as to provide a vacuum signal responsive to opening of the valve 70.

In operation, during engine off and idling conditions, throttle valves 25 are in essentially closed positions thereby providing essentially atmospheric pressure in EGR port 94. Accordingly, servo 72 maintains valve 86 closed, and no exhaust gas is recirculated from passage 60 to passage 62. The exhaust gas back pressure in line 128, together with spring 122, maintains the fuel metering valve 108 in the position shown in FIG. 4 blocking the fuel line 106.

During part throttle vehicle accelerations, rotation of the throttle valve to traverse port 94 causes manifold vacuum to be applied to servo 72. When the vacuum level is sufficient to overcome the chosen preload force of spring 90, valve 70 will open. Exhaust gases will then flow into the intake manifold runners 50 as controlled by orifice 61. Simultaneously, the suction in line 62 transmitted past valve 70 through lines 128 and 126 now acts on the end of valve 108. This together with the atmospheric pressure acting through the screw 118 on the opposite end of valve 108 moves the valve against the force of spring 122 to connect the fuel line segment 106 to the intake manifold line 62. The intake manifold therefore draws fuel through fuel duct 96 together with air through the bleed 100 to the engine cylinders. The added fuel is therefore discharged directly into the exhaust gases.

During wide open throttle accelerations, the manifold vacuum decays essentially to zero. Therefore, valve 70 will remain closed until the manifold vacuum recovers sufficient to overcome the force of spring 90 and again recirculate the exhaust gases. Additional fuel and air then also will be added in the manner as described above.

From the above, it will be seen that the invention improves engine driveability during exhaust gas recirculation by supplying a small amount of additional fuel and air to the engine whenever the exhaust gases are being recirculated, and that because both the EGR and supplemental fuel are metered by manifold vacuum across a fixed size orifice, the flow is essentially proportional to EGR flow.

While the invention has been shown and described in its preferred embodiment, it will be clear to those skilled in the arts to which it pertains that many changes and modifications may be made thereto without departing from the scope of the invention.

We claim:

1. An exhaust gas recirculating system for an internal combustion engine having intake and exhaust manifolding and a carburetor with an induction passage connected to the intake manifold and having a throttle valve movable across the passage to open and close the passage to control the flow therethrough, a duct connecting the intake and exhaust manifolding for recirculating the exhaust gases back into the engine, an exhaust gas recirculating (EGR) control valve movable between alternate positions to open and close the duct, a vacuum servo having an actuator connected to the (EGR) valve and having spring means biasing the (EGR) valve to a closed position, a vacuum signal line connected to the servo for moving the (EGR) valve to an open position in response to a predetermined vacuum force acting on the servo, means connecting the vacuum signal line to a port in the induction passage located adjacent the closed position of the throttle valve to be traversed by the throttle valve during throttle valve opening movements whereby the signal line fluid force varies from an essentially atmospheric pressure level at closed throttle valve positions to manifold vacuum levels in response to the throttle valve moving above the port, and fuel supply means connected to the intake manifold to supply fuel into the duct in response to opening of the (EGR) valve providing flow of exhaust gases through the duct.

2. A system as in claim 1, the fuel supply means including a fuel line connected to the intake manifold and a control valve in the fuel line normally blocking the fuel line and moved to open the fuel line in response to the induction of exhaust gases through the duct.

3. A system as in claim 1, the fuel supply means including a fuel source, conduit means connecting the fuel from the source to the intake manifold, a reciprocable fuel control valve in the conduit means movable between first and second positions blocking and unblocking the conduit means, spring means biasing the valve to the first position, and second conduit means connecting the control valve to the duct between the (EGR) valve and exhaust manifolding for movement of the valve to the second position in response to flow of gases through the duct.

4. A system as in claim 2, including air supply means connected to the fuel line for the induction of air simultaneous with the induction of fuel.

5. A system as in claim 1, the engine including an exhaust gas containing crossover passage passing beneath the induction passages of a carburetor attached to the engine to warm the passages, the duct being connected at one end to the crossover passage, and a pressure tap connected to the fuel supply means and to the duct between the (EGR) valve and exhaust gas passage for sensing the flow of exhaust gases through the duct upon opening of the (EGR) valve to effect the flow of fuel to the intake manifold.

6. A system as in claim 5, the fuel system including a fuel source, a conduit connecting the source to the intake manifold, and a fuel control valve in the conduit operably movable in response to the pressure in the tap applied to the control valve upon flow of gases through the duct to open the second conduit means to flow fuel to the intake manifold.

7. A system as in claim 6, including spring means biasing the control valve to a position closing the conduit, the control valve being moved to a position opening the conduit in response to a predetermined pressure differential between atmospheric pressure acting on one side of the control valve and the vacuum signal force of the pressure tap acting on the opposite side.

8. A system as in claim 7, including an air conduit connected to the conduit for the induction of air with fuel.

9. A system as in claim 1, the fuel supply means including a source of fuel, a first conduit connecting the source to the intake manifolding, a differential pressure operated reciprocating fuel control valve in the conduit, spring means acting on one end of the valve biasing it towards a first position blocking the conduit, means applying atmospheric pressure to act in the opposite direction on the opposite end of the control valve to urge it towards an open position permitting flow of fuel to the intake manifolding, a second conduit connecting a portion of the duct between the (EGR) valve and the exhaust manifolding to the one end of the control valve whereby the exhaust gas backpressure in the second conduit acting on the control valve during a closed condition of the (EGR) valve maintains the control valve blocking flow of fuel through the first conduit, opening of the (EGR) valve effecting a differential pressure acting on the control valve moving it to open the second conduit to permit flow of fuel, the movement of the control valve varying as a function of the change in pressure of the exhaust gas flow.

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