

[54] VACUUM BIAS REGULATOR ASSEMBLY

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[22] Filed: May 25, 1973

[21] Appl. No.: 364,141

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

[51] Int. Cl. F02m 25/06

[58] Field of Search 123/119 A

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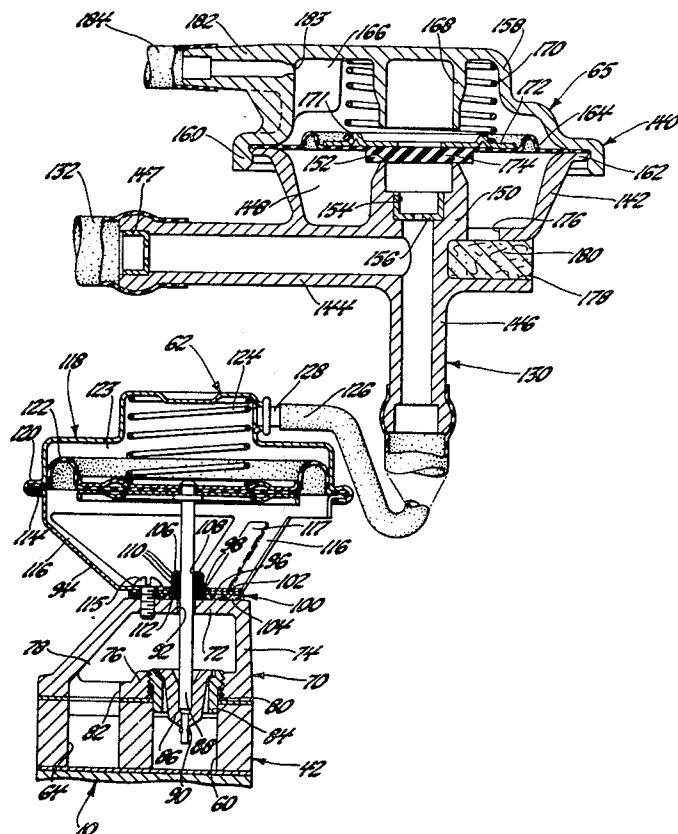
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ABSTRACT

An exhaust gas recirculation control system includes a diaphragm operated control valve assembly, responsive either to vacuum conditions at an induction passage slot traversed by the edge of the throttle or to exhaust back pressure, controls recirculation of exhaust gases from the intake manifold exhaust crossover passage to the intake manifold induction passages; a vacuum bias regulator assembly is responsive to intake manifold to bleed atmospheric pressure to the diaphragm operated valve at lower manifold vacuums to cut-off recirculation during off-idle and low part throttle ranges of vehicle operation.

1 Claim, 4 Drawing Figures



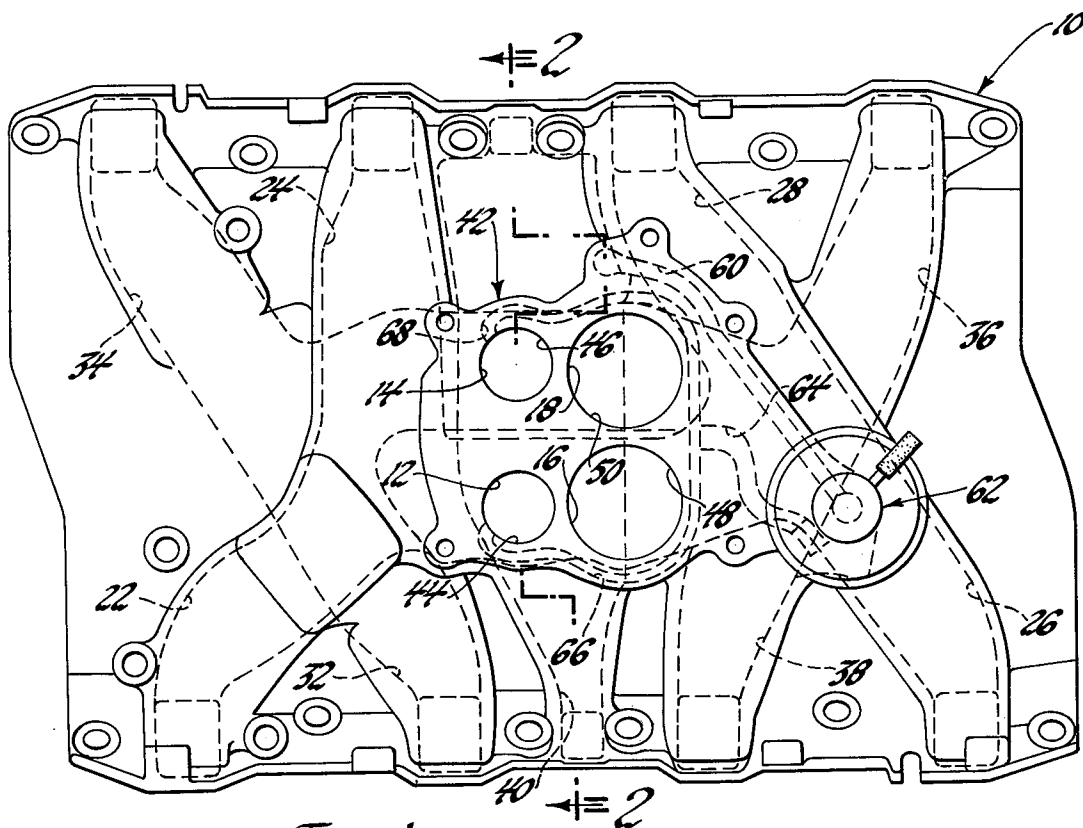


Fig. 1

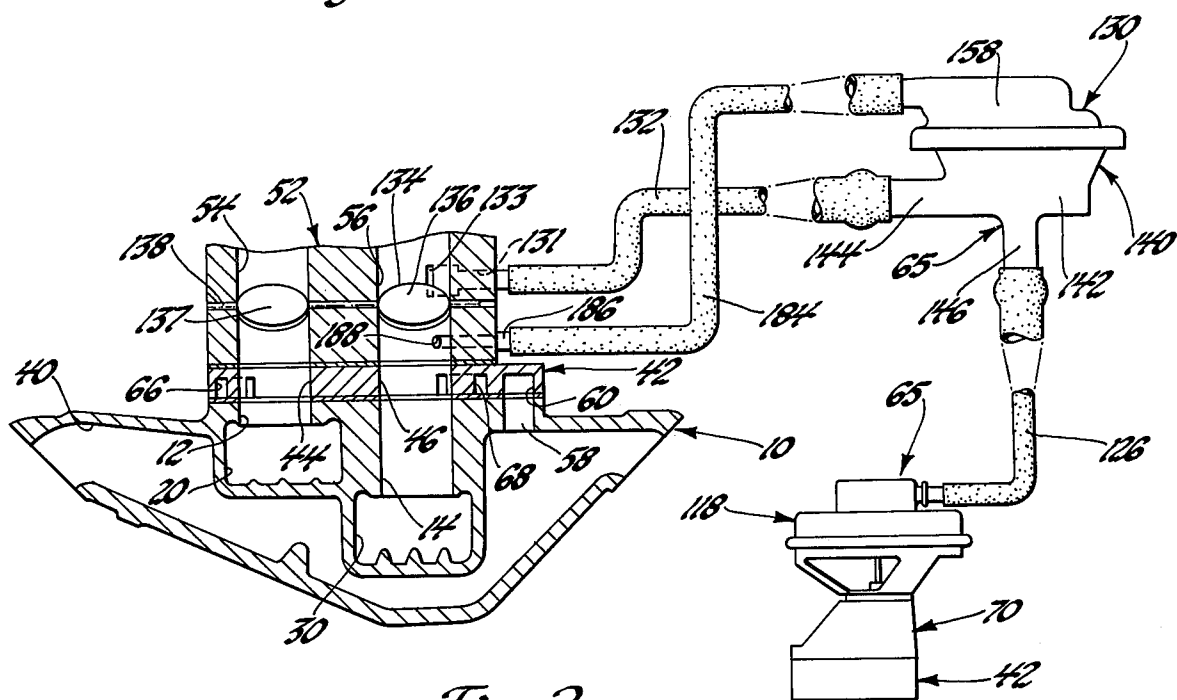


Fig. 2

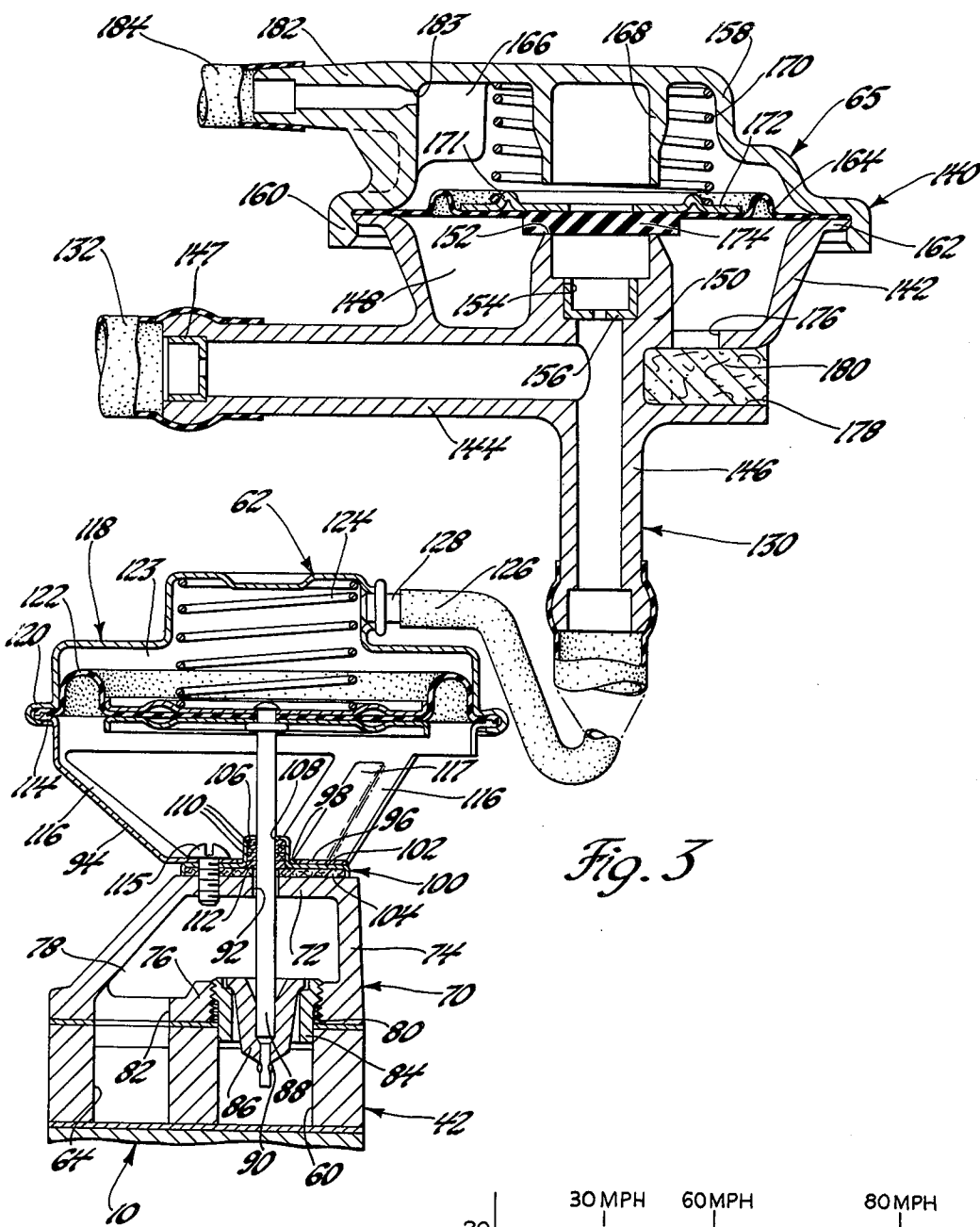
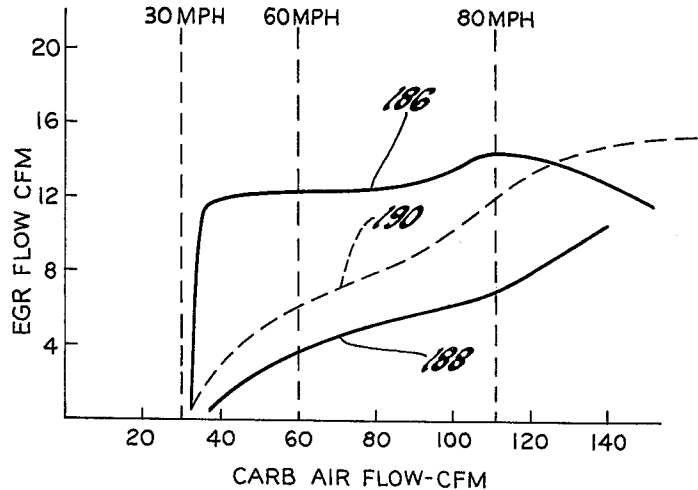


Fig. 3

Fig. 4



VACUUM BIAS REGULATOR ASSEMBLY

This invention relates to exhaust gas recirculation and more particularly to a novel exhaust gas recirculation control system including a valve assembly designed to control recirculation of exhaust gases and a vacuum bias regulator assembly operative in response to intake manifold vacuum to control bleed of atmospheric pressure to the valve assembly to reduce exhaust gas recirculation during off-idle and low part throttle operation of the vehicle. Important features of the vacuum regulator design include utilization of intake manifold for regulation of a vacuum signal produced by throttle movement across an induction passage slot and wherein a common regulator housing includes control vacuum inlet and outlet conduits as well as a bleed chamber having a filter therein to a regulator chamber with a valve controlled bleed port to the outlet conduit.

The details as well as other objects and advantages of this invention are shown in the drawings and set forth in the description of the preferred embodiments.

IN THE DRAWINGS

FIG. 1 is a top plan view of a V-8 engine intake manifold containing induction passages and an exhaust crossover passage, together with a carburetor spacer plate containing an exhaust gas recirculation passage and carrying an exhaust gas recirculation control valve assembly;

FIG. 2 is a transverse sectional view taken generally along line 2—2 of FIG. 1, showing the induction passage plenums and the exhaust crossover passage in the manifold and the inlet to the exhaust gas recirculation passage in the spacer plate, to which a carburetor throttle body has been added along with a vacuum regulator and exhaust gas recirculation valve in elevation;

FIG. 3 is an enlarged sectional view showing the details of the vacuum operated exhaust gas recirculation control valve assembly and the vacuum regulator; and

FIG. 4 graphically illustrates the exhaust gas recirculation flow created at different induction air flow rates under various vehicle operating modes.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIGS. 1 and 2, an intake manifold 10 has a pair of vertical primary riser bores 12 and 14 and a pair of vertical secondary riser bores 16 and 18. Riser bores 12 and 16 open to an upper horizontal plenum 20 connected forwardly (leftwardly as viewed in FIG. 1) to a pair of transverse runners 22 and 24 and connected rearwardly (rightwardly as viewed in FIG. 1) to another pair of transverse runners 26 and 28. Similarly, riser bores 14 and 18 open to a lower horizontal plenum 30 connected forwardly to a pair of transverse runners 32 and 34 and rearwardly to another pair of transverse runners 36 and 38.

An exhaust crossover passage 40 extends transversely from the left-hand side of manifold 10 beneath plenums 20 and 30 and receives a portion of the exhaust gases discharged from the engine combustion chambers. Exhaust crossover passage 40 may be blocked at the right-hand side if desired.

An insert plate 42 is secured on manifold 10 and has primary riser bores 44 and 46 and secondary riser bores 48 and 50 which meet, respectively, riser bores 12, 14, 16, 18 of manifold 10.

A carburetor 52 is secured on insert plate 42 and has primary throttle bores 54 and 56 which meet, respectively, primary riser bores 44 and 46 of insert plate 42. Carburetor 52 also has secondary throttle bores (not shown) which meet secondary riser bores 48 and 50 of insert plate 42.

A bore 58 in manifold 10 leads upwardly from exhaust crossover passage 40 to the first portion 60 of an exhaust recirculation passage formed in insert plate 42.

The first portion 60 of the exhaust recirculation passage leads through a control valve 62 to a second portion 64 of the exhaust recirculation passage as best shown in FIG. 1. This second portion 64 divides into a pair of branches 66 and 68 which lead to the primary riser bores 44 and 46 in insert plate 42.

It should be appreciated that both portions 60 and 64 of the exhaust recirculation passage may be integrated in manifold 10 rather than in separate insert plate 42.

One embodiment of an improved exhaust recirculation control system 65 is shown in detail in FIG. 3. It includes control valve 62 which comprises a base member 70 having an upper wall 72, a peripheral wall 74, and a lower wall 76 which define a chamber 78. Chamber 78 has an inlet 80 opening from the first portion 60 of the exhaust gas recirculation passage and an outlet 82 opening to the second portion 64 of the exhaust gas recirculation passage. A valve seat member 84 is threadably secured in inlet 80 in a tamperproof location.

A valve pintle 86 has a generally conical contour cooperating with valve seat 84 to provide a variable area for flow of recirculation exhaust gases. Valve pintle 86 is retained on a valve stem 88 by staking the end 90 of stem 88. Stem 88 extends upwardly through an opening 92 in the upper wall 72 of base member 70.

A housing member 94 has a central portion 96 provided with an opening 98 receiving valve stem 88.

An intermediate member 100 has an annular, downwardly concave, dished portion 102 disposed between the central portion 96 of housing member 94 and the upper wall 72 of base member 70. An asbestos insulating disc 104 is received in the dished portion 102 of intermediate member 100 and reduces conduction of exhaust heat from base member 70 to housing member 94.

Intermediate member 100 also has a central, downwardly concave, cupped portion 106 with a central opening 108 receiving valve stem 88. A plurality of graphited asbestos sealing discs 110 and a steel washer 112 are received in the cupped portion 106 of intermediate member 100 and engage valve stem 88 to guide stem 88 and to reduce air flow into chamber 78 through openings 108 and 92. The aforesaid components are held together by suitable fastener means such as screws 115 directed through portion 96, member 100, disc 104 into threaded engagement with wall 72, one screw 115 being shown in FIG. 3.

Housing member 94 has an outer rim 114 supported by three outwardly extending spokes 116 (only two of which appear in the figure). Each spoke 116 has a slightly raised rib 117 for reinforcement. Spokes 116 provide a minimized path for heat conduction from the central portion 96 of housing member 94 to the rim 114 of housing member 94.

A cover member 118 has a rim 120 secured about rim 114 of housing member 94. A diaphragm 122 is clamped between rims 114 and 120 to define an enclosure.

sure 123 between diaphragm 122 and cover 118. Diaphragm 122 carries valve stem 88. A spring 124 exerts a downward bias on diaphragm 122, valve stem 88, and valve pintle 86 to engage valve pintle 86 with valve seat 84.

A hose 126, secured to a fitting 128 opening from chamber 123, forms a vacuum signal conduit extending to a vacuum bias regulator assembly 130. A passage 131 within carburetor 52 connects an inlet hose 132 to regulator assembly 130 with a slot 133 opening from throttle bore 56. Slot 133 is disposed adjacent and extends above and slightly below the upstream edge 134 of the carburetor throttle 136 which is rotatably disposed in throttle bore 56 on a throttle shaft 138.

In operation, an air-fuel mixture, or air alone in the case of a fuel injected engine, will be drawn into the engine through the induction passage defined by carburetor throttle bores 54 and 56, insert plate riser bores 44, 46, 48, 50 and manifold riser bores 12, 14, 16 and 18, manifold plenums 20 and 30, and manifold runners 22, 24, 26, 28, 32, 34, 36, 38. When throttles 136 and 137 are closed as shown in FIG. 2, the substantially atmospheric pressure in throttle bore 56 above throttle 136 bleeds into the upper portion of slot 133 and reduces the induction vacuum sensed by the lower portion of slot 133. The resultant vacuum signal delivered through passage 131 and hoses 132, 126 to chamber 123 is insufficient to raise diaphragm 122 against the bias of spring 124. Valve pintle 86 is thereby maintained in engagement with valve seat 84 to prevent recirculation of exhaust gases through control valve chamber 78.

As throttles 136 and 137 are opened to a part throttle position, the upstream edge 134 of throttle 136 traverses slot 133 and a greater portion of slot 133 is subjected to the induction vacuum below throttle 136 while a lesser portion of slot 133 is subjected to the substantially atmospheric pressure above throttle 136. The resultant vacuum signal transferred through passage 131 and hoses 132, 126 to chamber 123 raises diaphragm 122 against the bias of spring 124. Valve pintle 86 is then lifted away from valve seat 84 to recirculate exhaust gases from exhaust crossover passage 40 through bore 58, passage 60, inlet 80, chamber 78, outlet 82, passage 64, and branches 66 and 68 to riser bores 44 and 46.

The rate at which exhaust gases are recirculated through control valve 62 is determined by the contour of pintle valve 86 and by the lift of valve 86, the pressure differential between exhaust crossover passage 40 and insert plate primary riser bores 44 and 46 being sufficient to maintain flow through control valve 62 at or near sonic velocity. The exhaust gas recirculation flow rate is determined by the vacuum signal created by the slot 133, which, as shown in FIG. 4, is proportional to the rate of induction air flow. The precise value of the vacuum signal may be controlled by the contour of slot 133 and its orientation with respect to throttle 136.

As throttles 136 and 137 approach wide open position, the induction vacuum below the throttles becomes insufficient to hold diaphragm 122 against the bias of spring 124. Valve pintle 86 thereupon re-engages valve seat 84 to prevent recirculation of exhaust gases.

When the throttle 136 is in its off-idle and low part throttle range of operation, it is difficult to properly calibrate carburetor slots such as 133 in FIG. 2. In such

throttle positions exhaust gas recirculation required for emission control can be reduced to a minimum. When the throttle 136 is in the outer end of part throttle and wide open throttle positions, there is a lower engine manifold vacuum. Also, during this phase of operation, a higher rate of exhaust recirculation is required for emission control. In order to closely regulate the operation of an exhaust gas recirculation control valve 62, the vacuum bias regulator assembly 130 is interposed in the system to produce a fixed bleed of atmospheric air to the exhaust gas recirculation valve signal port conduit 128 to cause the valve pintle 86 to be maintained closely thereby reducing recirculation of gas when the throttle is in its off-idle and low part throttle ranges of vehicle operation thereby to eliminate the problem of close calibration of a slot such as 133 in FIG. 2.

More particularly, the vacuum regulator assembly 130 includes a body 140 made up of a base portion 142 with an integral inlet conduit 144 and an integral outlet conduit 146 thereon. As best seen in FIG. 3, the inlet conduit 144 is connected to the inlet hose 132 from the carburetor slot 133. It includes an orifice plate 147 at the entrance thereof for metering vacuum flow from the carburetor to the regulator 130. The inlet conduit 144 intersects the outlet conduit 146 in a right angular relationship to complete a flow path for vacuum from the carburetor to the hose 126 thence to the vacuum signal conduit 128 leading to the control valve 62.

The housing base 142 forms a first compartment 148 having a centrally located boss 150 therein with a valve seat 152 formed on the top thereof. The boss 150 includes a bleed port 154 therein which communicates the compartment 148 with the outlet conduit 146 across an orifice plate 156 for controlling the rate of flow of fluid from the compartment 148 into the outlet conduit 146.

Additionally, the vacuum regulator 130 includes a cover or closure member 158 with an outer peripheral flange 160 thereon fixedly secured to an upper radial flange 162 of the base housing 142. The outer periphery of a flexible diaphragm member 164 is interposed between the flange 160 and the flange 162. Member 164 serves to seal the compartment 148 from a compartment 166 formed within the cover member 158. The cover member includes a dependent tubular portion 168 that is at the center thereof with a terminus end that serves as a stop against movement of the flexible diaphragm 164 upwardly within the compartment 166.

A bias spring 170 is located in surrounding relationship to the tubular portion 168 and has one end thereof in engagement with the inner surface of the cover member 158 and the opposite end thereof in engagement with an annular ridge 171 on a support plate 172 which is supportingly received on the surface of the flexible diaphragm 164 exposed to the compartment 166. The flexible diaphragm 164 further includes a centrally located integrally formed valve portion 174 that is located in overlying relationship with the seat 152 to be in engagement therewith in the opposite position as shown in FIG. 3. The housing base 142 includes a bleed port 176 therein located on one side of the boss 150 in communication with a generally rectangularly shaped space 178 in the housing base 142 on the opposite side of the inlet conduit 144 to define a flow passage to atmosphere. An air filter element 180 fills the

space 178 so as to remove particulate matter from air passing across the space 178 thence through the bleed port 176 to the compartment 148 to form one part of an air bleed passage which is completed across the bleed port 154 and orifice 156 in the boss 150 to the conduit 146 when the valve portion 174 is moved into an open position with respect to the seat 152.

Vacuum bias regulator 130 further includes an inlet fitting 182 with a reduced diameter bore 183 on the cover member 158 thereof which overlies the inlet conduit 144. It is connected to one end of a vacuum signal conduit 184 having the opposite end thereof connected to a fitting 186 on the carburetor 52 which leads to an intake manifold vacuum port 188 within the throttle bore 46.

The compartment 166 thereby is in direct communication with the vacuum conditions within the intake manifold of the vehicle.

Under conditions where the throttles 136, 137 are located in an off-idle or low part throttle range of operation where only a minimal amount of exhaust gas recirculation is required and where it is difficult to calibrate the vacuum level of control produced by the slot 133 in the carburetor bore 46, the intake manifold vacuum will be of a full magnitude. The bias spring 170 is set to maintain the valve element 174 against the seat 152 to prevent air bleed to the outlet conduit 146 thence to the control valve 62 until a vacuum level of ten inches of mercury is attained in the conduit 184 at which point the vacuum level within the compartment 166 will overcome the bias of the spring 172 to produce a first phase of system control wherein an air bleed is completed from the space 178 across the bore 154 and orifice 156 into the outlet conduit 146. This will cause a pressure condition within the enclosure 123 of control valve 62 so as to cause it to hold the valve pintle 86 seated against the valve seat 84 thereby to reduce recirculation of exhaust gas from the exhaust manifold to the induction passageway of the engine. This operation helps reduce exhaust gas recirculation flow at fast idle, cold start conditions and helps to eliminate the need for close carburetor port signal tolerance at the slot 133 since the air bleed will positively regulate the control valve to reduce any port sensitivity at idle conditions.

Vacuum conditions at the intake manifold to cause an air bleed to the control valve 62 to cause it to close the valve pintle also can occur on vehicle deceleration to help keep the recirculation valve closed during this phase of vehicle operation.

Additionally, the vacuum conditions that will override the bias spring 170 in the compartment 166 as produced by the intake manifold to produce bleed of air to the outlet conduit 146 so as to maintain the pintle 86 closed is made dependent upon engine vacuum conditions or vehicle speed in a manner not otherwise available in systems using a vacuum controlled slot such as 133 in the carburetor 52 as the sole means for supplying the control signal to the enclosure 123. Under such conditions, as shown in the graph of FIG. 4, the normal exhaust gas recirculation flow rate for vehicle operating at different speeds under a normal road load is shown by curve 186. Without the vacuum bias regulator and the control function of the bias valve 174 therein, the signal produced by the slot 133 in the carburetor bore 46 will cause a relatively substantial rate of exhaust gas flow at vehicle speeds in excess of 30

mph. Under such operating conditions, the vehicle engine load is relatively low and under such circumstances a high exhaust gas recirculation flow rate is not required.

By virtue of the operation of the aforescribed vacuum regulator 130, under such conditions, the vacuum level in the intake manifold is reduced to a point at which the compartment 166 is evacuated so as to cause the valve 174 to move away from the seat 152 so as to produce an atmospheric bleed into the outlet conduit 146 which will produce a modulation of the vacuum in the enclosure 123 so as to position the valve pintle 86 with respect to the seat 84 to reduce the rate of exhaust gas recirculation flow as shown by the curve 188 in FIG. 4. The reduced vacuum signal to the enclosure 123 and the resultant positioning of the valve pintle 86 improves drivability at normal road loads through the various speeds of vehicle operation without increasing emission levels.

Under high engine load conditions where the intake manifold vacuum is reduced, the bias spring 170 will maintain the valve portion 174 against the seat 152 thereby to maintain the exhaust gas recirculation control of the valve 62 under the conditions shown in curve 186 representing the normal road load exhaust gas recirculation rate in a system without the vacuum biasing control action of the regulator 130.

Under an intermediate intake manifold vacuum condition produced by vehicle acceleration to maintain eight inches of mercury vacuum, the control function of the system 65 is represented by the curve 190 in FIG. 4. This curve shows an intermediate range of exhaust gas recirculation flow rates. The vacuum bias regulator 130 alters the port valve function so that valve 62 will reverse exhaust gas recirculation flow between road load conditions in curve 186 and acceleration that maintains the eight inches of mercury condition with the resultant recirculation shown in curve 190.

While the embodiment of the present invention, as herein disclosed, constitute a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A vacuum regulating system for controlling a vacuum signal to a vacuum operated exhaust gas recirculation valve comprising: means including a throttle bore slot and a throttle valve movable across the slot to define a first throttle responsive variable vacuum source, means including the intake manifold of an internal combustion engine to define a second variable vacuum source, a pressure regulator housing having a first vacuum conduit thereon connected to the throttle bore slot, said regulator housing including a second vacuum conduit directly intersecting said first conduit for directly communicating said first variable vacuum source to the vacuum operated exhaust gas recirculation valve, said housing including a base forming a first compartment having an upstanding valve seat therein including a bore therethrough directly in communication with said second vacuum conduit, a cover member having a circumferential flange thereon attached to said base, a flexible diaphragm interposed between said cover member and said base for defining a second compartment with said cover and for separating said first compartment from said second compartment, said base including an opening therein for communicating said first compartment with atmosphere, a spring located within said second compartment for biasing said dia-

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phragm towards said seat, an integral valve portion centrally of said diaphragm located within said first compartment in overlying relationship to said seat for sealing said seat, means including a third vacuum conduit connected to said cover member for communicating said second compartment with said second variable vacuum source, said diaphragm being responsive to an engine intake manifold vacuum that exceeds a predetermined vacuum level to position said integral valve portion open with respect to said seat thereby to directly communicate said second vacuum conduit with

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atmosphere to reduce the vacuum signal from said first variable vacuum source to the vacuum operated exhaust gas recirculation valve, said flexible diaphragm being responsive to an intake manifold vacuum level below said predetermined vacuum level to cause said spring to move said diaphragm and the integral valve portion thereon to close said seat thereby to direct the full vacuum signal from said first variable vacuum source to the vacuum operated exhaust gas control valve.

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