

[54] VACUUM SIGNAL CONTROLLER FOR
TRANSMISSION CONTROLLED EMISSION
DEVICE

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F02M 25/06[58] Field of Search 74/843, 856, 857, 860;
123/119 A; 60/278, 290

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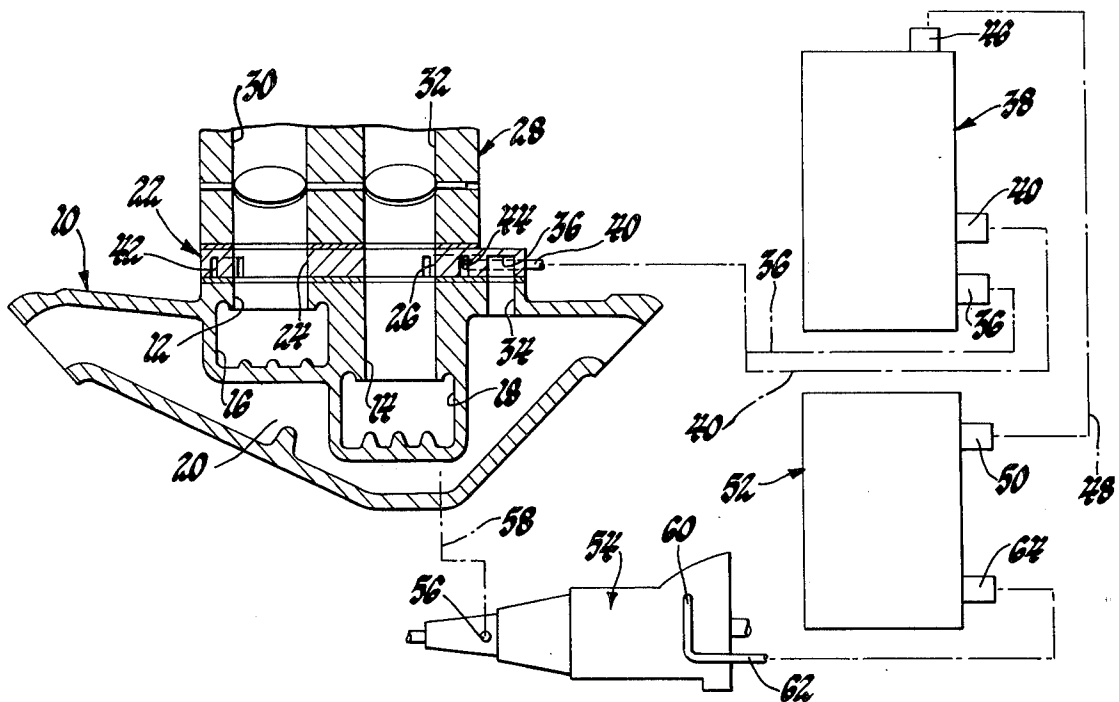
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[57] ABSTRACT

An exhaust gas recirculation control system including a hydraulic transmission with valves for producing a hydraulic control signal reflecting intake manifold vacuum and for producing a governor speed signal that are combined and applied to a hydraulic motor that operates a converter to produce a modulated vacuum signal applied to a vacuum operator that positions an exhaust gas recirculation control valve to regulate exhaust flow between the engine exhaust and exhaust gas recirculation ports to the intake manifold in accordance with mass flow of air-fuel through the intake manifold of the internal combustion engine.

4 Claims, 9 Drawing Figures



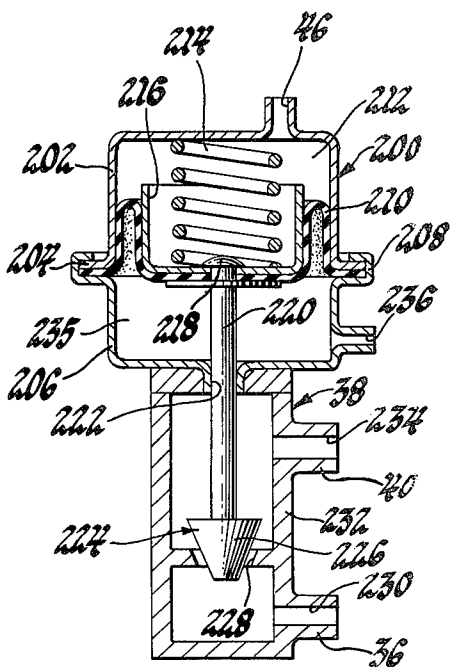


Fig. 6

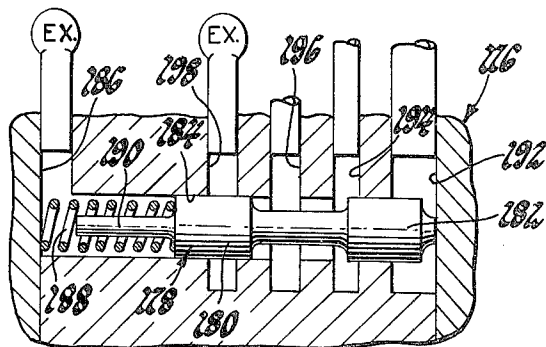


Fig. 5

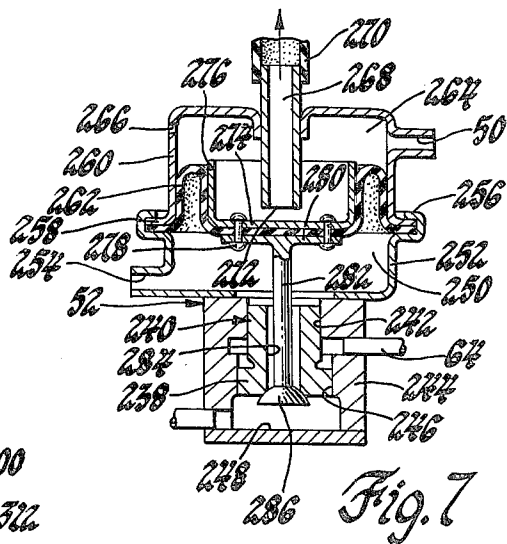


Fig. 7

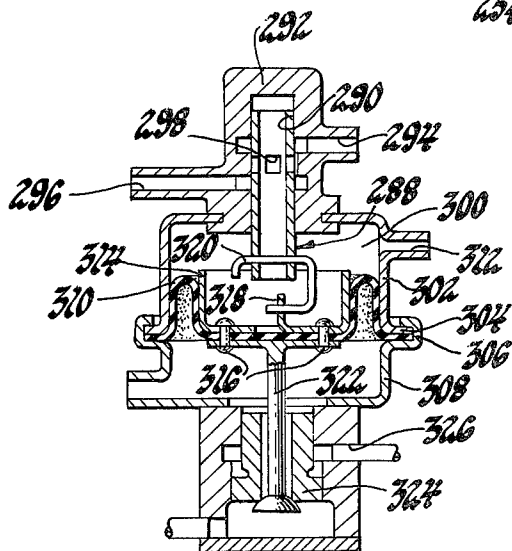


Fig. 8

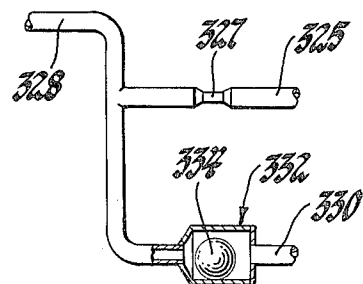


Fig. 9

VACUUM SIGNAL CONTROLLER FOR TRANSMISSION CONTROLLED EMISSION DEVICE

This invention relates to exhaust gas recirculation systems for internal combustion engines and more particularly to such systems including a regulator valve for proportioning exhaust gas recirculation in accordance with engine operating conditions.

Present systems include a vacuum operated exhaust gas recirculation control valve that is under the control of vacuum signals from a ported vacuum source in the throttle bore of a carburetor. At idle and wide open throttle, a low ported vacuum condition occurs which conditions the exhaust gas recirculation valve closed. At part throttle conditions, the ported vacuum is high so as to condition the recirculation valve opened thereby to maintain a maximum flow of exhaust gas recirculation.

In order to obtain optimum reduction of vehicle emissions by use of a vacuum signal responsive exhaust gas recirculation valve, it is preferable to control recirculation in accordance with the mass flow of air and fuel to the engine under all operating conditions with exhaust gas recirculation being terminated under wide open throttle conditions.

Accordingly, an object of the present invention is to improve the control of exhaust gas recirculation from an engine exhaust to the intake manifold by the provision of an exhaust gas recirculation control valve positioned by a vacuum operator and wherein a modulated vacuum control signal is directed to the vacuum operator from a converter which produces a modulated vacuum signal proportional to a hydraulic signal from an automatic hydraulic transmission for the vehicle reflecting the intake manifold pressure and the speed of operation of the vehicle so as to accurately reflect the mass flow of air and fuel into the engine.

Another object of the present invention is to provide an improved emission control system for an internal combustion engine that utilizes existing valve means in a hydraulic transmission for the vehicle including means for sensing the line pressure of a hydraulic supply in the transmission and a speed responsive governor pressure signal therein and further responsive to intake manifold pressure of the vehicle to produce a modulated pressure signal for use in the transmission and by the further provision of additional valve means that differentiates the modulated pressure signal to produce a hydraulic control signal that reflects intake mass flow conditions in the vehicle under a wide range of engine operating conditions and further including means for converting the hydraulic signal to a vacuum control signal which conditions a vacuum controlled exhaust gas recirculation valve to maintain exhaust gas recirculation between the exhaust passage and intake manifold in accordance with mass flow conditions in the engine.

Yet another object of the present invention is to provide an improved converter assembly for use in a hydraulic transmission controlled exhaust gas recirculation system including means for converting a hydraulic signal from the transmission which reflects both intake manifold pressure and vehicle speed conditions to a modulated vacuum signal that is proportional to both intake manifold pressure and vehicle speed for operating a vacuum controller in an exhaust gas recirculation valve so as to maintain the exhaust gas recirculation valve in a regulated position that will maintain the re-

circulation of exhaust gas from the engine exhaust to the intake manifold in accordance with a wide range of engine operating conditions including changes in speed, load and carburetor throttle positions thereby to reduce vehicle emissions and wherein the vacuum signal is terminated at wide open throttle conditions.

Still another object of the present invention is to provide an improved hydraulic signal to air signal converter including housing means having an air bleed port and a vacuum port and further including a movable diaphragm for forming a controlled vacuum chamber within said housing in communication with both of the aforesaid ports and wherein an atmospheric control chamber is formed in the housing on the opposite side of the diaphragm to bias the diaphragm in a first predetermined direction to maintain the controlled vacuum chamber under atmospheric conditions and wherein hydraulic motor means are connected to the diaphragm and operated in response to a hydraulic signal from a transmission to move the diaphragm in an opposite direction so as to selectively communicate the vacuum port with the controlled vacuum chamber to produce a modulated vacuum signal in accordance with the hydraulic signal that is suitable for use in controlling a vacuum operated exhaust gas recirculation control valve for regulating communication between the exhaust passage and an intake manifold passage of an internal combustion engine.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the Drawings:

FIG. 1 is a diagrammatic view of a transmission controlled exhaust gas recirculation control system including the present invention;

FIG. 2 is a transverse sectional view of a modulator control valve for use in the system of FIG. 1;

FIG. 3 is a sectional view of a manifold reference valve in the transmission of FIG. 1;

FIG. 4 is a sectional view of a signal valve in the transmission of FIG. 1;

FIG. 5 is a sectional view of an exhaust gas recirculation signal valve in the system of FIG. 1;

FIG. 6 is a vertical sectional view of an exhaust gas recirculation valve;

FIG. 7 is a vertical sectional view of a hydraulic vacuum converter in the system of FIG. 1;

FIG. 8 is a vertical sectional view of a second embodiment of a converter; and

FIG. 9 is a diagrammatic view of another control signal circuit.

Referring first to FIG. 1, an intake manifold 10 has a pair of riser bores 12 and 14 which open to lower horizontal plenums 16, 18, respectively connected to transverse runners, not shown, for directing air-fuel flow to engine intake valves.

An exhaust crossover passage 20 extends transversely from the left-hand side of manifold 10 beneath plenums 16 and 18 and receives a portion of the exhaust gases discharged from the engine combustion chambers.

An insert plate 22 is secured on manifold 10 and has riser bores 24 and 26 which meet, respectively, riser bores 12, 14 of manifold 10.

A carburetor 28 is secured on insert plate 22 and has throttle bores 30 and 32 which meet, respectively, riser

bores 24 and 26 of insert plate 22.

A bore 34 in manifold 10 leads upwardly from exhaust crossover passage 20 to a first portion 36 of an exhaust recirculation passage formed in insert plate 22. The first portion 36 of the exhaust recirculation passage leads through an exhaust gas control valve 38 to a second portion 40 of the exhaust recirculation passage. This second portion 40 divides into a pair of branches 42 and 44 which lead to the primary riser bores 24 and 26 in insert plate 22.

It should be appreciated that portions 40, 42 and 44 of the exhaust recirculation passage may be integrated in manifold 10 rather than in separate insert plate 22.

In the present invention, the exhaust gas recirculation control valve 38 includes a vacuum signal port 46 that is connected by a conduit 48 to a controlled vacuum output port 50 in a hydraulic air converter 52. An automatic transmission 54 in the vehicle train includes valve means 56 communicated by means of a conduit 58 to the intake manifold 10 which is combined by means to be described to produce a hydraulic signal that reflects both intake manifold pressure and vehicle speed. The signal is directed through a port 60 from the transmission 54 thence through a conduit 62 to a hydraulic signal port 64 on the converter 52.

Transmission 54 is standard hydraulic transmission of the type including a fluid supply pump therein for producing transmission line pressure for regulating the operation of control valves within the transmission and an exhaust pressure system in communication with a hydraulic pump vented to atmosphere. The transmission further includes a modulator valve 66, as best seen in FIG. 2, and a governor 67 which produces a pressure signal in accordance with vehicle speed.

The modulator valve 66 includes a valve member 68 including a piston 70 and plurality of spaced lands 72 and 74, with the lands 72, 74 having a diameter differing from that of piston 70. End 76 of the piston 70 is vented at port 78 and piston 70 is acted upon by a force generated by manifold pressure from conduit 58 operating on a diaphragm assembly 80 with a movable pin 82 which biases the valve member 68 against pressures acting on land 74. The land 74 is located in a bore 84 forming a chamber 86 below the land 74. A passage 88 through the land 74 communicates chamber 86 with either a transmission line pressure passage 90 or a transmission exhaust passage 92 in valve 66 in accordance with the position of the valve member 68 therein. The valve further includes a governor pressure passage 94 that is communicated with an output signal from the governor 67 through suitable conduit means 96.

By virtue of the aforescribed arrangement, the valve member 68 will be shifted in response to changes in intake manifold pressure against line pressure and governor pressure to produce an output signal through a modulator pressure passage 98 which is related to engine manifold pressure and vehicle speed by a relationship set forth by the following equation:

$$(1) \quad P_m = \frac{F}{A_a} - P_o \left(\frac{A_b}{A_a} - 1 \right)$$

The terms in the aforescribed equation are as set forth below.

P_m = modulator valve pressure signal

F = operating force on piston 70 produced by manifold pressure

A_a = cross-sectional area of lands 72 and 74

P_o = governor pressure signal

A_b = cross-sectional area of piston 70

The modulator valve 66, previously described, is found in automatic transmissions of the type shown in U.S. Pat. No. 3,321,056, issued May 23, 1967, to F. J. Winchell et al. The governor signal produced for use in the aforescribed system is more particularly set forth in U.S. Pat. No. 2,762,384, issued Sept. 11, 1956, to M. S. Rosenburger.

The transmission control system further includes a manifold reference valve 100 which is illustrated in FIG. 3. It takes the transmission modulator pressure from passage 98 and converts it back to a reference pressure which is proportional to manifold pressure. More particularly, the valve 100 includes a valve member 102 having lands 104, 106 thereon slidably supported in a first bore 108. A second land 109 on the valve 102 is supportingly received in bore 110 having a cross-sectional area less than the area of lands 104, 106. The land 104 has a passage 112 therethrough communicating a chamber 114 with a transmission line pressure passage 116 or a transmission exhaust passage 120 dependent on the position of valve 102. An output passage 118 therefore has a pressure signal directed to it that is proportional to manifold pressure. A governor pressure passage 122 directs transmission governor pressure to the backside of the land 106 and against the foreside of the land 109 which has the opposite face thereon in communication with a modulator pressure passage 124 which is in communication with the passage 98 from the modulator pressure valve 66. The selected valve diameters can be modified to meet the demands of the transmission control and engine emission system.

The valve 100 thereby is controlled in accordance with the governor pressure and modulator pressure to selectively control flow from line pressure and to exhaust to establish the pressure reference signal at passageway 118 in accordance with the following equation:

$$P_{124}A_{109} + P_{122}(A_{106} - A_{109}) = P_{118}A_{106} \quad (2)$$

In order to produce a hydraulic signal that accurately reflects mass flow conditions into the induction passages of an internal combustion engine, it is necessary to further incorporate a signal that reflects engine speed.

Accordingly, in the control system of the present invention a signal valve 126 is included having a valve element 128 therein including spaced apart lands 130, 132 located in a valve bore 134. The valve 128 is coupled by an interconnecting pin 136 to another valve 137 having a plurality of lands 138, 140, 142 with progressively decreasing diameters operating in bores 144, 146, 148, respectively.

The land 130 has one end thereof located in a pressure chamber 150 connected to transmission governor pressure. It controls communication between an exhaust passage 152 and reference signal pressure passage 158 which is in communication with the output passage 118 from valve 100. An output signal is generated in passage 154. The land 132 has an end-to-end passage 156 therethrough communicating passage 152 or 158 with chamber 160.

In order to produce an output signal in passage 154 which further reflects engine speed conditions, the signal valve 126 further includes a passage 162 located between the lands 138 and 140 which is in communication with a transmission pressure having a direct clutch pressure therein reflecting a pressure condition P_{2-3} in a transmission of the type shown in U.S. Pat. No. 3,321,056 to Winchell et al, which occurs at an upshift between second and third speed ranges. Further, the valve includes a passage 164 therein in communication with a transmission pressure reflecting an intermediate clutch pressure condition P_{1-2} which occurs after an upshift from first to second speed ranges. The valve further includes a passage or chamber 166 therein in communication with a passage 168 to the exhaust side of the hydraulic system of a transmission. A further exhaust passage 170 communicates with the end of the land 138 opposite the passage 162.

By virtue of the aforescribed valve assembly 126, a signal pressure is produced in passageway 154 designated P_a that can be utilized to control the exhaust gas recirculation valve 38. The output pressure P_a is a reflection of the governor pressure limited by the reference manifold pressure from valve 100 and reduced by transmission speed signal P_{2-3} and P_{1-2} . The output signal is thereby established by the following operating equation which neglects the area of interconnecting end 136 and is derived on the basis of the pressure in chamber 166 being exhausted.

$$(4) \quad P_{154} = P_{150} - P_{162} \frac{A_{138} - A_{140}}{A_{130}} - P_{164} \frac{A_{140} - A_{142}}{A_{130}}$$

where P_a designated P_{154} cannot exceed P_{158} .

For most operation, the signal pressure will have characteristics related to engine RPM and manifold pressure as determined by the transmission from vehicle operation.

As will be noted, the pressure signal P_a is a function of engine speed and yet will be limited by manifold pressure; that is, for low manifold pressure it will be limited to a low value and at intermediate manifold pressures it will be limited to a higher value.

The signal produced at passage 154 of valve 126 exists at wide open throttle and therefore is not completely desirable for exhaust gas recirculation control if a straight hydraulic system is used such as that described in my copending United States application, Ser. No. 403,929, filed Oct. 5, 1973. In such a system detent control pressure can be applied to passage 168 of valve system 126 shown in FIG. 4 or a recirculation signal valve 176 shown in FIG. 5 can be incorporated. This is not required when a hydraulic air converter 52, FIG. 1 is used.

One end of the shuttle valve 178 is in communication with an exhaust passage 186. A bias spring 188 in bore 184 engages the exhaust end of the shuttle valve 178 around a stop pin 190 thereon. The opposite end of the shuttle valve is located in a passage 192 in communication with a detent pressure system in a transmission of the type shown in U.S. Pat. No. 3,321,056 to Winchell et al. This system will be pressurized in accordance with wide open throttle conditions to produce a pressure signal on the shuttle valve 178 that will cause it to compress spring 188 and move the lands 180, 182 in a direction to block an input signal passage 194 in communication with the outlet from the signal passage 154

of valve 126 and will communicate an exhaust gas recirculation pressure signal passage 196 therein with an exhaust passage 198 whereby the manifold and engine speed responsive signal in passage 154 is blocked from the output signal passage 196 in valve 176 at wide open throttle conditions. When a hydraulic air converter 52 is used, passage 154 of valve 126 can be connected directly to hydraulic signal port 64 of converter 52.

Referring now to FIG. 6, the exhaust gas recirculation control valve 38 includes a vacuum operator 200 with a housing defined by an upper cap portion 202 with a flange 204 joined to a base portion 206 by a turned over flange 208 thereon. A movable diaphragm 210 has its peripheral edge connected between the cap portion 202 and the base portion 206 to form a vacuum chamber 212. A spring 214 within the vacuum chamber 212 has one end thereof in engagement with the cap portion 202 and the opposite end thereof in engagement with a diaphragm piston 216. A rivet 218 secures the piston 216 to a valve operator stem 220 which is biased downwardly with respect to a bore 222 formed in the base 206. The stem 220 is connected at its opposite end to a valve element 224 having a contoured peripheral wall 226 thereon concentrically arranged with respect to an exhaust gas control orifice 228 located between an inlet port 230 formed in a valve housing 232 which is communicated across the orifice 228 with an exhaust gas port 234. Ports 230, 234 are connected respectively to the first and second portions 36, 40 of the exhaust gas recirculation passage in the system of FIG. 1.

The base portion 206 defines an atmospheric chamber 235 and includes an atmospheric vent port 236 therein to maintain chamber 235 at atmospheric pressure to oppose the action of the compression spring 214. The exhaust valve member 224 is maintained in a closed position with respect to the orifice 228 until a predetermined vacuum signal is directed to the vacuum signal port 46.

The exhaust gas recirculation is fully closed at engine idle and wide open throttle ported conditions when the vacuum applied to the port 46 is low. At part throttle conditions, the hydraulic signal from the transmission port 60 which reflects mass flow of fuel and air into the intake manifold 10 is applied to the converter 52 to produce a vacuum signal to the operator 200 to cause the valve 224 to open thereby to produce exhaust gas recirculation.

More particularly, as seen in FIG. 7, the hydraulic signal from the aforescribed transmission control valve arrangement is applied via converter port 64 to a piston 238 formed on one end of a spool element 240 that is supportingly received for sliding movement within a bore 242 of a hydraulic motor housing 244 in the converter 52. The piston 238 is slidably supported for reciprocation in a larger diameter bore 246 that communicates with an atmospheric vent passage 248 in the housing 244 that is adapted to be communicated with the transmission sump.

The opposite end of the spool element 240 is exposed to atmospheric pressure in a chamber 250 formed by a base housing portion 252. The base portion 252 includes a port 254 therein vented to the transmission sump and an inwardly turned flange 256 thereon in engagement with a flange 258 on a housing cap 260. A movable diaphragm 262 has its peripheral flange connected between the flanges 256, 258 to form a controlled vacuum chamber 264 with the housing cap 260.

The chamber 264 is in communication with atmosphere across a small bleed orifice 266 and is selectively communicated with intake manifold pressure through a tube 268 having an open end thereon located exteriorly of the housing to be connected by means of a conduit 270 to the intake manifold and an opposite open end 272 that is located axially inwardly of the chamber 264 in spaced relationship to an end wall 274 on a cup-shaped diaphragm piston 276 secured by suitable means representatively shown as rivets 278 to the diaphragm 262 and a plate 280 in juxtaposed relationship with the atmospheric side of diaphragm 262.

The plate 280 connects to one end of a stem 282 that depends through a bore 284 formed axially through the spool element 240. The stem 282 includes a radially outwardly directed closure 286 thereon that restricts travel in relation to piston 238.

When there is a reduced hydraulic control pressure signal from the transmission representing engine operating conditions where it is desirable to terminate exhaust gas recirculation, the atmospheric pressure in chamber 250 will bias the diaphragm 262 upwardly within the controlled vacuum chamber 264 so as to move the wall 274 into sealing engagement with the open end 272 of the tube 268. This will cause a reduced vacuum condition within the chamber 264 with a resultant signal directed from the output port 50 to the vacuum signal port 46 of the operator 200. The reduced vacuum in the chamber 212 of the vacuum operator 200 will produce a resultant closing movement of the exhaust gas recirculation control valve.

When the hydraulic control signal increases in magnitude to reflect engine operating conditions where exhaust gas recirculation is required, the pressure will act on the piston 238 thereby to shift the spool element 240 downwardly with respect to the bores 242, 246. This will shift the stem 282 downwardly so as to open the end 272 of the tube 268 thereby to increase the vacuum level within the controlled vacuum chamber 264 and the increased vacuum as applied to the vacuum chamber 212 of the operator 200 will cause diaphragm piston 216 to compress the spring 214 thereby to move the exhaust gas recirculation valve element 224 out of sealed engagement with the walls of the orifice 228 to produce exhaust gas recirculation between the ports 230, 234.

In another embodiment of the invention shown in FIG. 8, the valving function produced by the wall 274 of the piston 276 and the open end 272 of the tube 268 is produced by a slide valve 288 that is slidably received in a bore 290 formed in a fluid fitting 292. The fitting 292 includes an atmospheric vent port 294 and an engine intake manifold vacuum port 296 each selectively communicated with a plurality of circumferentially spaced cross flow ports 298 in the slide valve 288 in accordance with its axial position within the bore 290. As in the case of the converter 52, a controlled vacuum chamber 300 is defined by a housing portion 302 having a radially outwardly directed flange 304 connected to an inturned flange 306 of a base housing portion 308. A movable diaphragm 310 has its periphery joined between the flanges 304, 306 to complete the chamber 300. A vacuum signal output port 312 like the signal port 50 in the converter 52 is communicated with the signal port of an exhaust gas recirculation control valve as shown in FIG. 6.

In this embodiment a diaphragm piston 314 is connected to the movable diaphragm 310 by suitable fas-

tening means such as rivets 316. It includes an upwardly formed tab 318 thereon joined by means of a generally U-shaped link 320 to the end of the slide valve 288. A stem 322 which corresponds to stem 282 is operated by a hydraulic motor 324 in response to a hydraulic signal at port 326 connected to the aforesaid transmission valve system. The stem 322 shifts the slide valve 290 downwardly in response to increased hydraulic signals so as to communicate the vacuum port 296 with the chamber 300 thereby to apply greater vacuum to the exhaust gas recirculation control valve to produce greater exhaust gas recirculation in the engine. Stem 322 shifts the valve 290 upwardly in response to reduced hydraulic pressure on the motor 324 so as to communicate the atmospheric vent 294 with the chamber 300 to produce a reduced vacuum signal to the exhaust gas recirculation valve thereby to terminate exhaust gas recirculation.

Another proposal for producing a hydraulic signal for association with the system of the type described above includes a simplified hydraulic circuit shown in FIG. 9 having a conduit 325 fluidly connected to the output conduit 98 from the transmission modulator valve 66. The conduit 325 includes a restricting orifice 327 and is in turn connected to a supply conduit 328 like supply conduit 62 in the first embodiment. Additionally, the system includes a second conduit 330 having a check valve 332 therein with a movable ball element 334 that will be maintained opened when the pressure in conduit 328 exceeds that in conduit 330. Conduit 330 is connected to a governor pressure signal from the transmission as applied through conduit 96.

Thus when governor pressure in conduit 330 is lower than modulator pressure in conduit 325, ball 334 will unseat such that the signal pressure in conduit 328 will be equal to governor pressure in conduit 330 and not modulator pressure in conduit 325. When governor pressure is higher than modulator pressure, ball 334 will be seated and the signal pressure in conduit 328 will be equal to modulator pressure. The control signal pressure in conduit 328 is therefore constructed and restrained by modulator pressure in accordance with intake manifold pressure and governor pressure which is a function of vehicle speed. This signal is then processed by converter 52 so as to regulate exhaust gas recirculation through the control valve 38.

While the embodiments 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:

1. An exhaust gas recirculation control system for use with an internal combustion engine having an induction passage for flow of air and fuel into the engine, an exhaust passage for exhaust flow from the engine and an exhaust gas recirculation passage having a first portion extending from said exhaust passage and a second portion extending to said induction passage comprising: transmission means including a hydraulic supply for producing line pressure and speed responsive governor means for producing a hydraulic speed signal related to vehicle speed, modulator valve means in said transmission including means sensing intake manifold pressure and said hydraulic speed signal and means for producing a hydraulic output signal from said modulator valve means related to intake manifold pressure and vehicle speed, second control valve means including means for sensing said modulator valve means output signal, transmission line pressure and the hydraulic output sig-

nal of said governor means to produce a hydraulic reference output signal proportional to manifold pressure, third valve means responsive to said hydraulic modulator reference signal to produce a hydraulic control signal in accordance with mass flow of air-fuel into the induction passage, an exhaust gas recirculation valve having an inlet connected to the first portion of the recirculation passage and an outlet connected to the second portion of the recirculation passage, means forming an orifice between said inlet and outlet, a valve element located within said orifice having wall means thereon movable relative to said orifice to vary exhaust gas recirculation flow between the exhaust passage and the induction passage, means for actuating said valve element including a vacuum operator having movable diaphragm means connected to said valve element and a vacuum chamber formed in part by said movable diaphragm means having an input signal port thereto, a converter housing having an engine intake manifold vacuum port and an atmospheric vent port therein, means including a movable diaphragm defining a pressure modulating chamber within said housing, said housing having a vacuum signal output port in communication with said modulating chamber, means for selectively shifting said diaphragm with respect to said housing in response to changes in said hydraulic control signal reflecting mass flow of air-fuel into the induction passage and converter valve means operative in response to diaphragm movement within said converter housing to produce a controlled vacuum level within said modulating chamber, and means for directing said controlled vacuum signal from said modulating chamber to said input signal port on said vacuum operator to position said exhaust gas recirculation valve element to control exhaust gas recirculation from the exhaust passage into the induction passage in accordance with mass flow of air-fuel into the induction passage during engine operation.

2. An emission control system for use on an internal combustion engine of the type having an intake manifold for flow of air and fuel to the engine and an exhaust passage for directing combustion products from the engine and an exhaust gas recirculation passage having a first portion extending from said exhaust passage and a second portion extending to said induction passage comprising: a hydraulic transmission including a hydraulic supply maintained at a predetermined line pressure and a speed responsive governor means for producing a hydraulic governor signal related to vehicle speed, valve means within said transmission for sensing intake manifold pressure and being responsive to said hydraulic governor signal to produce a resultant hydraulic control signal reflecting mass flow of air-fuel into the induction passage, an exhaust gas recirculation valve having an inlet connected to the first portion of the recirculation passage and an outlet connected to the second portion of the recirculation passage, means forming an orifice between said inlet and outlet, a valve element located within said orifice having wall means thereon movable relative to said orifice to vary exhaust gas recirculation between the exhaust passage and the induction passage, a vacuum operator connected to said valve element including a vacuum input signal port thereto, a converter housing having an atmospheric vent port and an engine intake manifold vacuum port thereto, means including a movable diaphragm forming a vacuum modulating chamber within said converter housing, said converter housing including a vacuum

output port therefrom for communicating said modulating chamber with the input signal port of said vacuum operator, and means responsive to said mass flow hydraulic output signal to shift said movable diaphragm within said converter housing, converter valve means responsive to movement of said diaphragm for selectively communicating said vacuum port with said vacuum modulating chamber so as to produce a vacuum signal from said converter reflecting mass flow of air-fuel in the induction passage, said last mentioned vacuum signal conditioning said vacuum operator to position said exhaust gas recirculation valve element so as to produce exhaust gas recirculation from the exhaust passage to the induction passage in accordance with mass flow through the induction passage of the internal combustion engine.

3. An exhaust gas recirculation control system for use on an internal combustion engine having an intake manifold for air-fuel flow to the engine and an exhaust passage for flow of combustion products from the engine and an exhaust gas recirculation passage having a first portion extending from said exhaust passage and a second portion extending to an induction passage within said intake manifold comprising: transmission means including a hydraulic supply maintained at a predetermined line pressure and speed responsive governor means for producing a hydraulic signal related to vehicle speed, valve means within said transmission including means for sensing the intake manifold pressure of the engine and said governor signal for producing a first hydraulic signal related to vehicle speed, modulator valve means in said transmission including means sensing engine induction passage pressure and said governor signal for producing a second hydraulic output signal related to induction passage pressure and speed, and control valve means including means responsive to said governor pressure and said modulator valve output signal to produce a third hydraulic signal for control of exhaust gas recirculation in response to mass flow of air-fuel into the induction passage, an exhaust gas recirculation valve having an inlet connected to the first portion of the recirculation passage and an outlet connected to the second portion of the recirculation passage, means forming an orifice between said inlet and outlet, a valve element located within said orifice having wall means thereon movable relative to said orifice to vary exhaust gas recirculation flow between the inlet and outlet, a vacuum operator for controlling said valve element including a vacuum signal port, a converter housing having an atmospheric vent port and an engine intake manifold vacuum port thereon, means including a movable diaphragm for forming a controlled vacuum modulating chamber within said converter housing, a vacuum output signal port on said housing in communication with said modulating chamber, a hydraulic motor housing having a bore therethrough including a movable spool element supportingly received therein with a piston thereon, a port within said motor housing for receiving said hydraulic transmission signal reflecting mass flow of air-fuel to the induction passage to produce a differential pressure on said spool piston to cause said spool to shift within said bore, an actuator stem including one end thereof connected to said diaphragm and the other end coupled to said spool, means forming an exhaust passage in said motor housing for communication with the transmission sump, means forming an atmospheric chamber between said movable diaphragm and said spool, means forming an ex-

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haust port in said converter housing for communicating said atmospheric chamber with the transmission sump, converter valve means responsive to movement of said movable diaphragm by said stem to control communication of intake manifold vacuum with said controlled vacuum chamber in accordance with movement of said stem to produce a controlled vacuum signal for said vacuum operator to position said exhaust gas recirculation valve element to maintain exhaust gas recirculation in accordance with mass flow of air fuel into said induction passage.

4. An exhaust gas recirculation control system for use on an internal combustion engine having an induction passage for air-fuel flow to the engine, an exhaust passage for flow of combustion gases from the engine and a recirculation passage having a first portion extending from the exhaust passage and a second portion extending to the induction passage comprising: exhaust gas recirculation control valve means including an inlet connected to the first portion of the recirculation passage and an outlet connected to the second portion of the recirculation passage, means forming an orifice between the inlet and outlet, valve means located within the orifice including a contoured wall portion thereon movable with respect to the walls of the orifice, a vacuum operator for positioning said valve means with respect to the orifice including a vacuum signal port thereto, a hydraulic transmission including a hydraulic supply having a predetermined line pressure and a sump maintained at atmosphere, said transmission further including speed responsive governor means for producing a hydraulic signal related to vehicle speed,

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modulator valve means within said transmission operative to produce an output signal related to induction passage pressure, a converter including an air bleed port thereto and a manifold inlet vacuum port, means defining a controlled vacuum chamber within said converter including a movable diaphragm, means including said movable diaphragm forming an atmospheric chamber for biasing said movable diaphragm in a first predetermined direction, converter valve means operated upon movement of said movable diaphragm in said first predetermined direction to block communication between said inlet vacuum port and said controlled vacuum chamber, means including a hydraulic motor for shifting said movable diaphragm in an opposite direction, means including a one-way check valve for directing said governor means hydraulic signal to said hydraulic motor, and means including a restrictor for communicating said output signal from said modulator valve means to said hydraulic motor, said combined governor pressure and modulator pressure signals acting upon said hydraulic motor to position said movable diaphragm against atmospheric pressure to maintain a controlled communication of said controlled vacuum chamber with said vacuum inlet port to produce a modulated vacuum output signal from said controlled vacuum chamber to condition said vacuum operator to control said exhaust gas control valve means to recirculate exhaust gas from the exhaust passage to the induction passage in accordance with mass flow of air-fuel through the induction passage of the internal combustion engine.

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