United States Patent

[11] 3,610,219

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[54] EXHAUST GAS RECIRCULATION CONTROL
2 Claims, 10 Drawing Figs.

[52] U.S. Cl. ..... 123/119 A, 123/32 EA, 123/139 AW
[51] Int. Cl. F02n 25/06
[50] Field of Search ..... 123/119 A, 119, 139 AW, 32 EA

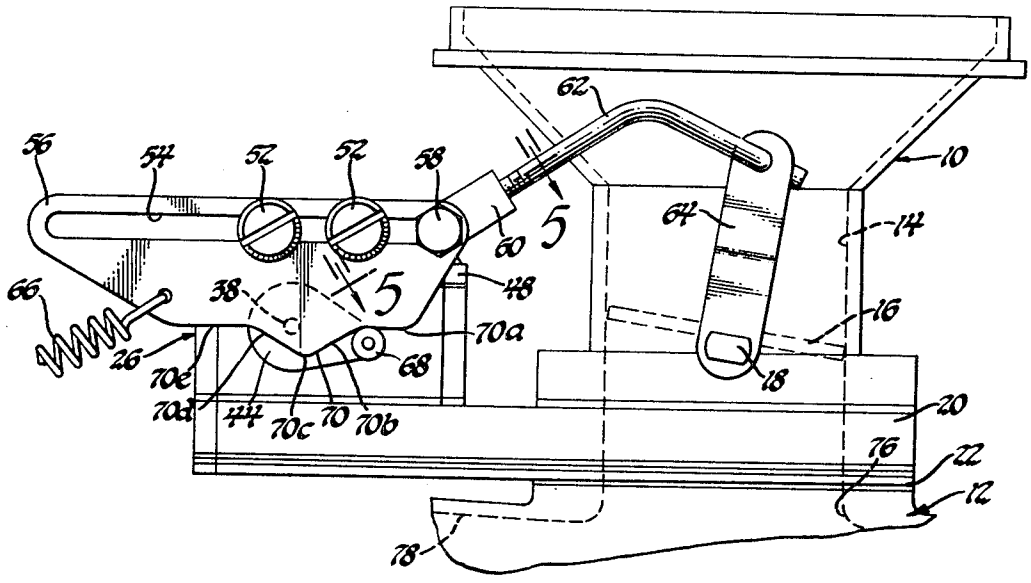
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Primary Examiner—Wendell E. Burns
Attorneys—J. L. Carpenter and C. K. Veenstra

ABSTRACT: In an internal combustion engine, exhaust gas is recirculated from the intake manifold exhaust gas crossover passage to the induction passage. An exhaust gas recirculation control valve is positioned by the throttle to proportion exhaust gas recirculation flow to induction airflow. In one embodiment, the exhaust gas recirculation passages are cast integrally in the intake manifold. Fuel metering in a timed fuel injection system responsive to manifold absolute pressure is compensated for exhaust gas recirculation.



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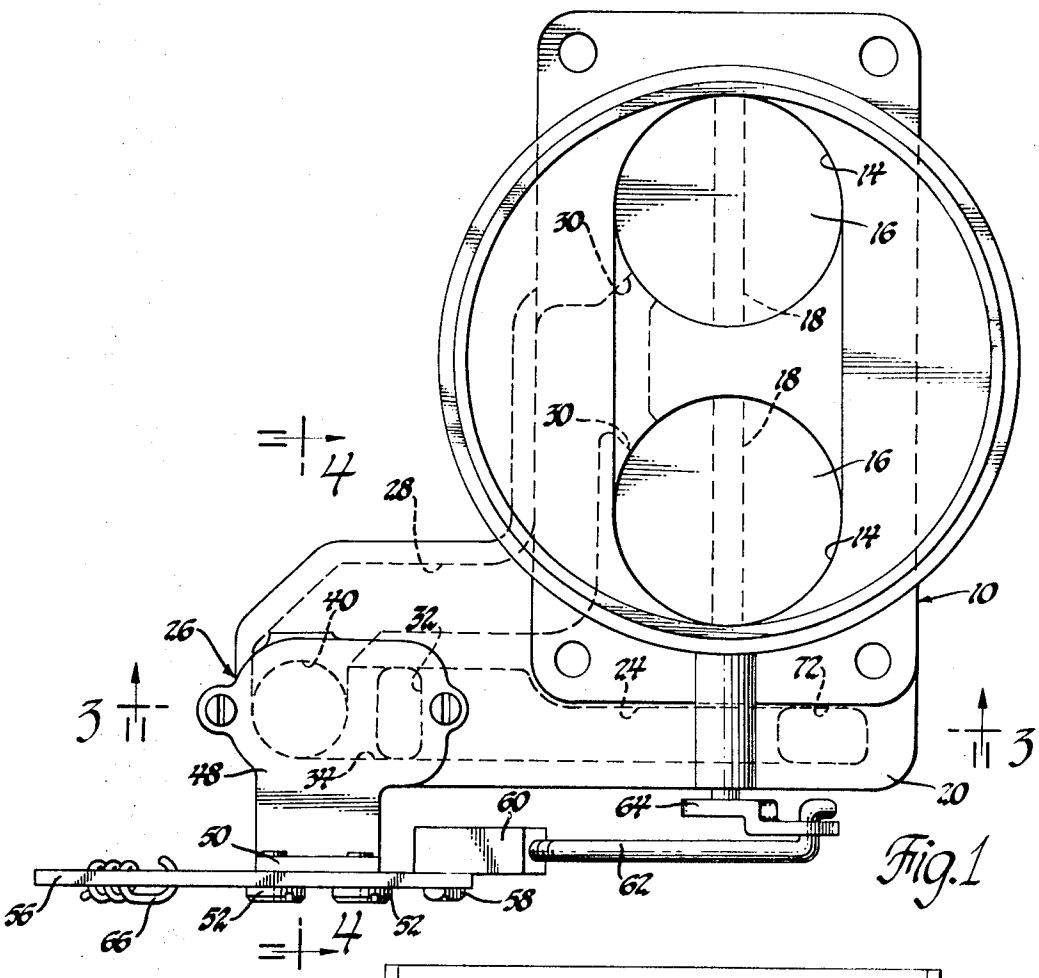


Fig. 1

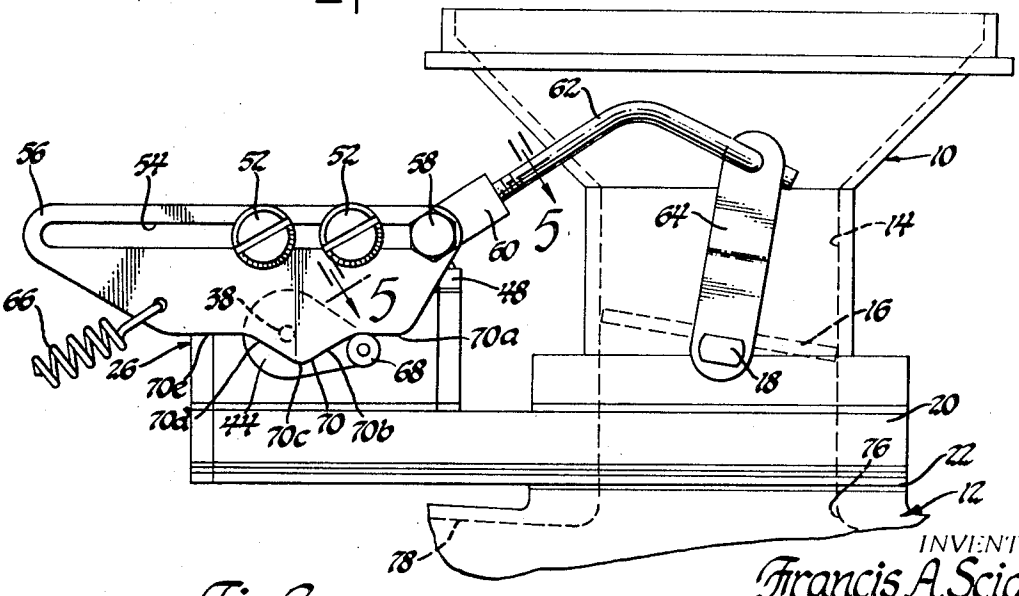


Fig. 2

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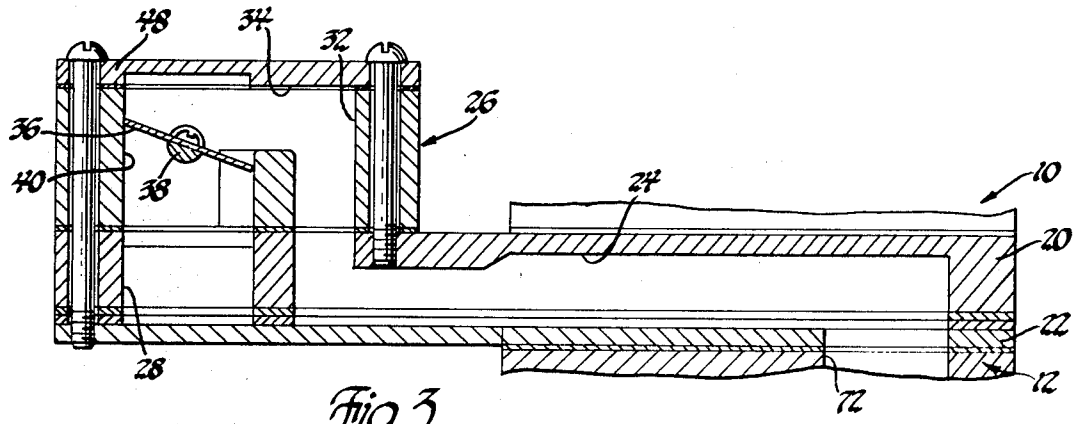


Fig. 3

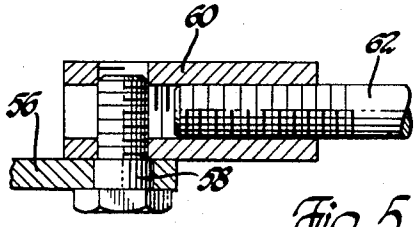


Fig. 5

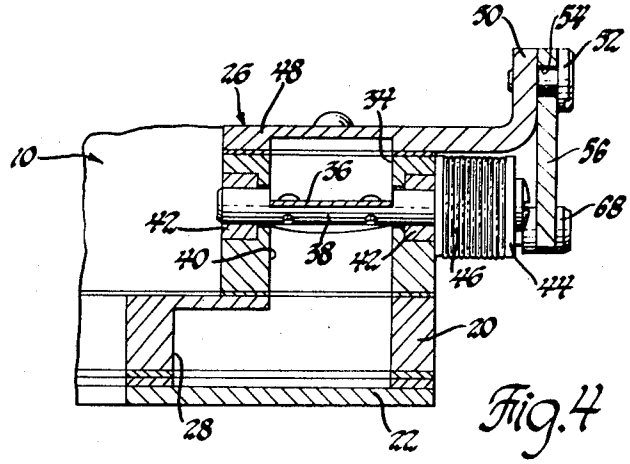


Fig. 4

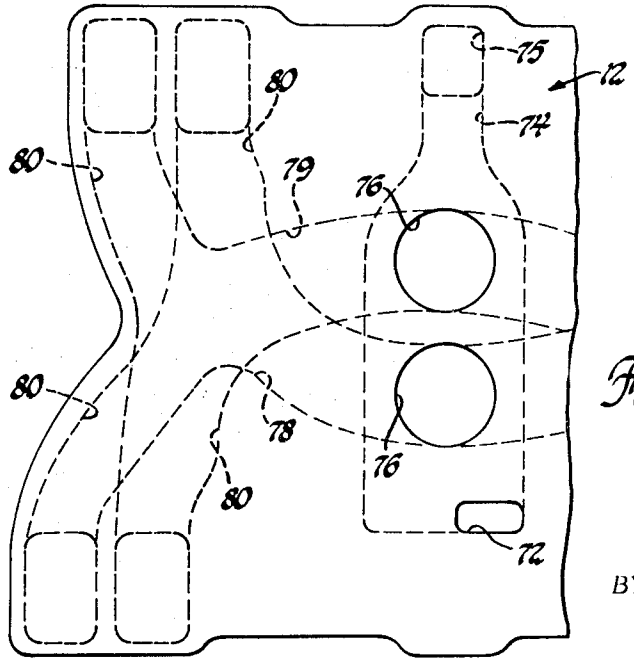


Fig. 6

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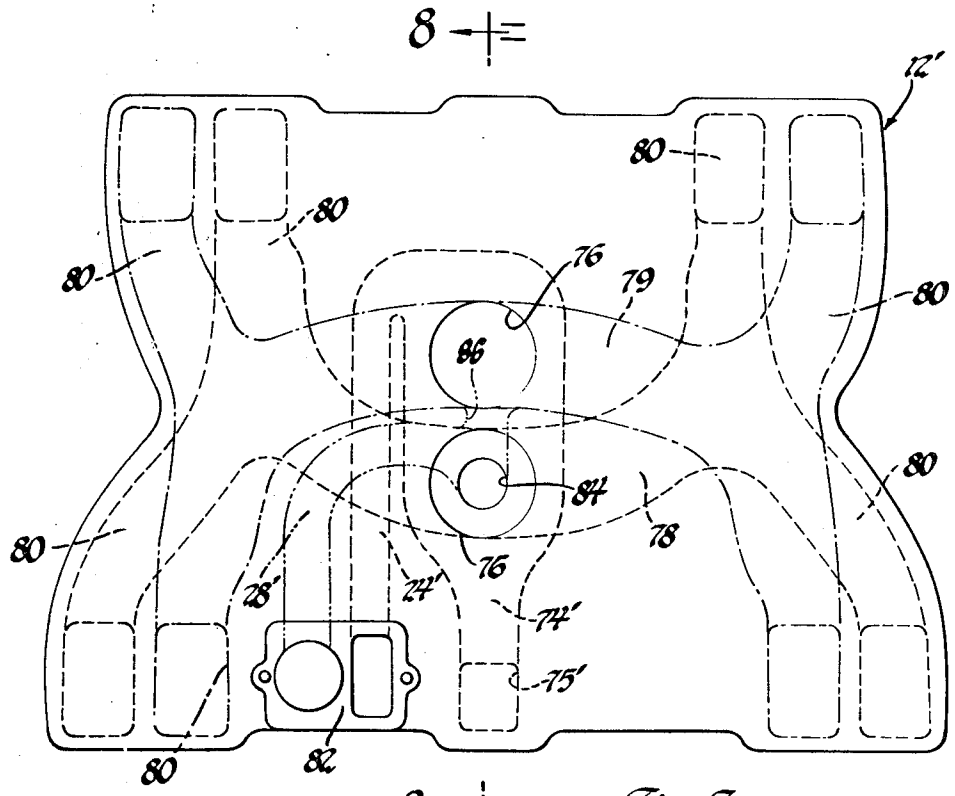


Fig. 7

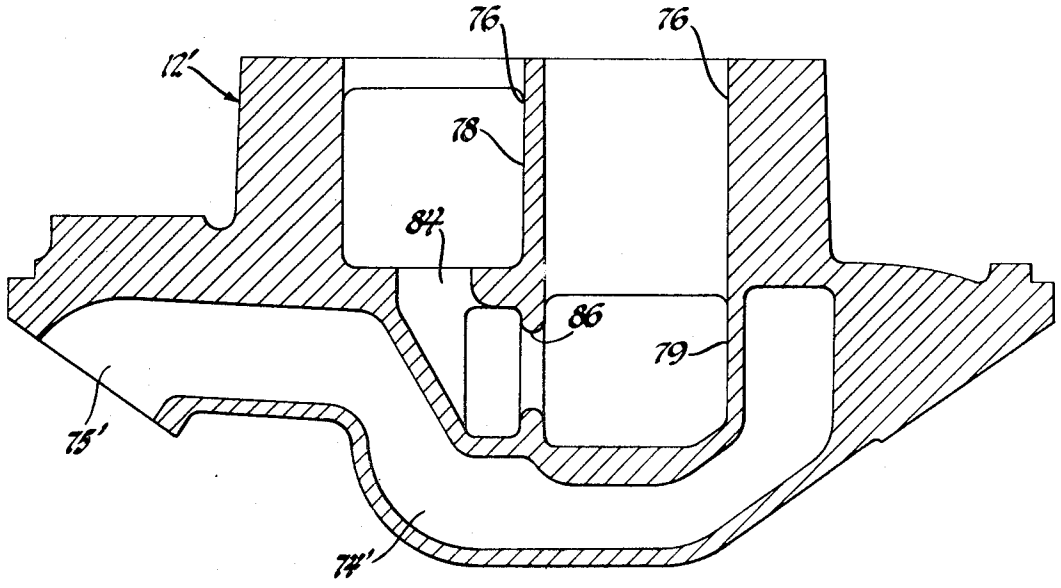


Fig. 8

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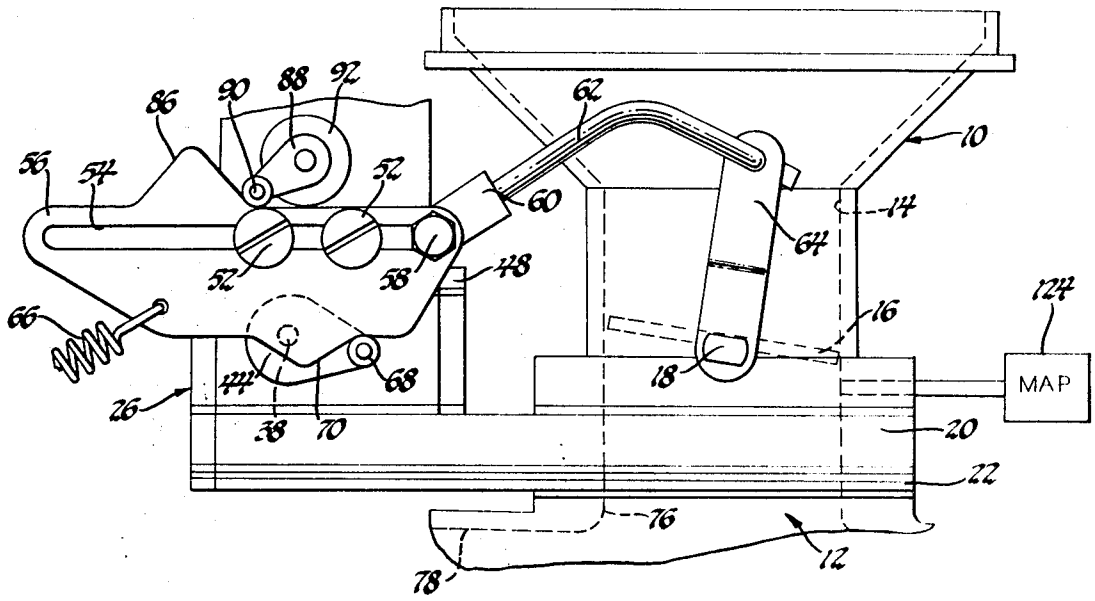


Fig. 9

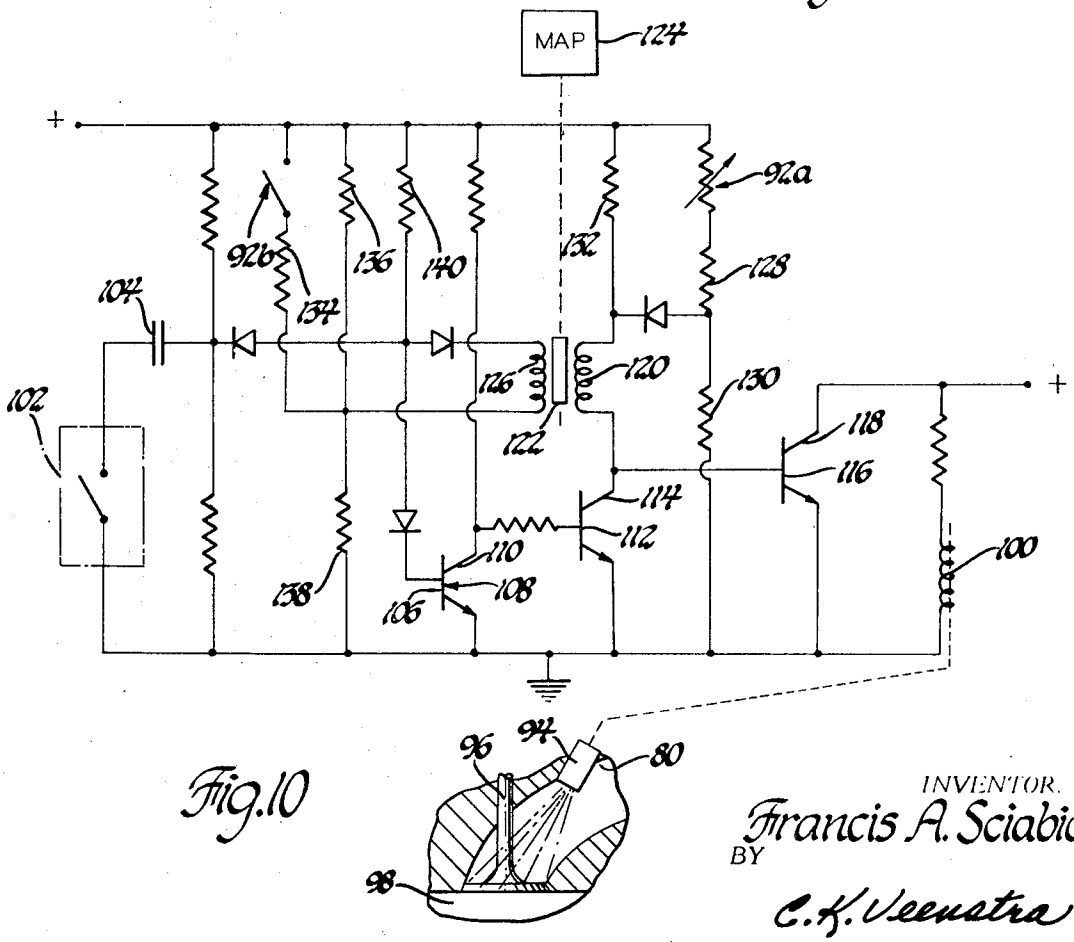


Fig. 10

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EXHAUST GAS RECIRCULATION CONTROL

This invention provides a control mechanism for an exhaust gas recirculation system. In this system, an exhaust gas recirculation control valve is positioned by the throttle through a linearly movable cam member which permits ready visualization and calculation of the position of the control valve. Thus the position of the control valve may be easily adjusted relative to the position of the throttle so that exhaust gas recirculation flow may be properly proportioned to induction airflow.

This invention further provides an exhaust gas recirculation control mechanism operated by the throttle in which the throttle may return to idle position even if the control valve or cam member were to remain at an intermediate position.

The details as well as other objects and advantages of this invention are set forth below and shown by the drawings wherein:

FIG. 1 is a top plan view of an induction passage throttle body and an exhaust gas recirculation control valve;

FIG. 2 is a side elevational view of the device shown in FIG. 1 illustrating the configuration of the cam member;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 1 illustrating the exhaust gas recirculation control valve;

FIG. 4 is a sectional view along line 4—4 of FIG. 1 illustrating the control valve-operating mechanism;

FIG. 5 is a sectional view along line 5—5 of FIG. 2 illustrating the adjustable connection in the linkage between the exhaust gas recirculation control valve and the throttle;

FIG. 6 is a top plan view of the FIG. 1 intake manifold illustrating the exhaust gas crossover passage;

FIG. 7 is a top plan view of an alternative intake manifold having integrally cast exhaust gas recirculation passages:

FIG. 8 is a sectional view taken along line 8—8 of FIG. 7 illustrating the openings from the exhaust gas recirculation passage to the induction passages;

FIG. 9 is a view similar to FIG. 2 illustrating the fuel metering compensating mechanism; and

FIG. 10 is a circuit diagram for an electronically controlled timed fuel injection system illustrating two embodiments of variable impedance devices for compensating the fuel metering.

Referring first to FIGS. 1 and 2, a throttle body assembly 10 is mounted on an intake manifold 12. A pair of induction passages 14 pass through assembly 10 and are controlled by a pair of throttles 16 disposed on a throttle shaft 18.

Inserted between throttle body assembly 10 and manifold 12 is a plate 20 and a base 22 which have extensions of induction passages 14. Plate 20 and base 22 define an exhaust gas recirculation inlet passage 24 leading to a control valve assembly 26 and an exhaust gas recirculation outlet passage 28 leading from control valve assembly 26. Branches 30 connect exhaust gas recirculation outlet passage 28 with induction passages 14 below throttles 16. For simplicity, exhaust gas recirculation inlet passage 24 will be referred to merely as exhaust gas recirculation passage 24, exhaust gas recirculation outlet passage 28 will be referred to as metered exhaust gas passage 28, and the two passages 24 and 28 will be referred to collectively as exhaust gas recirculation passages.

As shown in FIG. 3, exhaust gas recirculation control valve assembly 26 has an inlet bore 32 leading from exhaust gas recirculation passage 24 to an upper cross passage 34. A butterfly valve 36 is disposed on a shaft 38 in an outlet bore 40 leading from cross passage 34 to metered exhaust gas passage 28.

Shaft 38 is journaled on a pair of bushings 42 (FIG. 4) and has a lever 44 (FIGS. 2 and 4) secured on the outer end thereof. A torsion spring 46 (FIG. 4) biases shaft 38 and lever 44 in a counterclockwise direction as viewed in FIG. 2.

The cover 48 for control valve assembly 26 provides a bracket having an upstanding arm 50 (FIGS. 1 and 4) into which a pair of bolts 52 are threadedly secured. As shown in FIG. 2, bolts 52 extend through a slot 54 in a cam member 56, thereby supporting cam member 56 for linear motion.

An additional bolt 58 also extends through slot 54 and is secured to an adjusting nut 60. Adjusting nut 60 threadedly receives a link 62 connected to a throttle lever 64 secured on throttle shaft 18.

A spring 66 biases cam member 56 leftwardly as viewed in FIGS. 1 and 2.

In operation, clockwise opening movement of throttles 16, throttle shaft 18 and throttle lever 64 pulls link 62 and cam member 56 toward the right as viewed in FIG. 2. A cam follower 68 on control valve lever 44 is biased against a cam surface 70 on cam member 56. As is evident from FIG. 2, cam follower 68 successively contacts a first portion 70*a* in which control valve 36 remains closed, a first ramp 70*b* in which control valve 36 opens, a peak 70*c* in which control valve 36 remains open, a second ramp 70*d* in which control valve 36 closes, and a second portion 70*e* in which control valve 36 remains closed. The sequence is reversed as throttles 16 are closed and spring 66 returns cam member 56 toward the left.

Cam surface 70 is configured whereby control valve 36 begins opening movement when throttles 16 have been opened about 5°, reaches a fully open position when throttles 16 have been opened between 14° and 20°, and returns to closed position when throttles 16 have been opened about 34°.

As control valve 36 opens, exhaust gas received through exhaust gas recirculation passage 24 is admitted to metered exhaust passage 28 and delivered through branches 30 to induction passages 14.

It will be noted that since control valve 36 and cam member 56 are biased in a valve closing direction by springs 46 and 66, they exert no opening force on throttles 16. Moreover, even if control valve 36 or cam member 56 were to remain in an open position, throttles 16 would be free to close because bolt 58 rides toward the left in slot 54 as throttles 16 are closed.

EXhaust gas is received by exhaust gas recirculation passage 24 from an exhaust gas riser bore 72 connecting with an exhaust gas crossover passage 74 which passes through intake manifold 12. As may be seen in FIG. 6, intake manifold 12 includes a pair of conventional riser passages 76 which communicate with generally horizontal upper and lower plenum chambers 78 and 79 respectively. Plenum chambers 78 and 79 extend longitudinally from the bottom of riser passages 76 to transverse runner passages 80 at the ends thereof. Exhaust crossover passage 74 extends from an inlet 75 at one side of manifold 12, beneath riser passages 76 and plenum chambers 78 and 79, to exhaust gas riser bore 72.

It will be appreciated, of course, that induction passages 14, manifold riser passages 76, plenum chambers 78 and 79, and runner passages 80 may be collectively referred to as an induction passage.

FIGS. 7 and 8 show a modified intake manifold 12′ in which the exhaust gas recirculation and metered exhaust gas passages are cast integrally in the manifold. The FIG. 7 view is schematic and various combinations of dot-dash lines have been used to facilitate visualization of the different passages. As shown in these FIGS., a pair of riser passages 76 disposed on opposite sides of the manifold center line connect with upper and lower plenum chambers 78 and 79, respectively, which are generally horizontal and extend longitudinally through the manifold to transversely reaching runner passages 80.

An exhaust gas crossover passage 74′ extends from an inlet 75′ at one side of the manifold center line, beneath riser passages 76 and plenum chambers 78 and 79, to the opposite side of the manifold centerline. There exhaust gas crossover passage 74′ discharges into an exhaust gas recirculation passage 24′. Passage 24′ leads to a pad 82 which is adapted to receive control valve assembly 26. Alternatively, an exhaust gas recirculation control valve of different design could be received in a pocket in manifold 12′. A metered exhaust gas passage 28′ extends from pad 82, above exhaust gas recirculation passage 24′ above exhaust gas crossover passage 74′, and under upper plenum chamber 78 to a pair of ports 84 and 86. Port 84 opens vertically into the bottom of upper plenum chamber 78 and is centered below the associated riser passage 76. Port 86 opens horizontally into lower plenum chamber 79.

Thus exhaust gas is recirculated through a crossover passage to heat the induction passages and is then delivered through a control valve assembly into the induction passages.

It will be noted that all exhaust gas recirculated to the engine is delivered through the exhaust gas crossover passage to heat the induction passages, and all exhaust gas delivered through the exhaust gas crossover passage is recirculated to the engine. Thus the exhaust gas recirculation control valve controls both the flow of exhaust gas for heating the induction passages and the flow of exhaust gas recirculated to the engine. This combination proves advantageous under conditions such as wide open throttle operation where exhaust gas recirculation and induction passage heating should be reduced for maximum power. It should be recognized, however, that the advantages of this manifold structure are not limited to a system in which all exhaust gas flowing through the exhaust gas crossover passage is recirculated to the induction passages.

FIG. **9** illustrates a modification of the FIG. **2** device whereby fuel metering may be compensated for exhaust gas recirculation. The FIG. **9** device is identical to that of FIG. **2**, supplemented by an additional cam surface **86** on cam member **56**. Concurrently with movement of control valve lever **44** by cam surface **70**, cam surface **86** operates a lever **88** through a cam follower **90** carried by lever **88**. Lever **88** controls a unit **92** to vary an impedance which controls fuel metering as explained below.

FIG. **10** is a schematic diagram of an electronically controlled timed fuel injection system. As shown therein, a fuel injector **94** directs fuel into an intake manifold runner passage **80** at the back of an inlet valve **96** for a combustion chamber **98**. Injector **94** is operated by a solenoid **100** during each cycle of the engine, and fuel is metered by controlling the duration of time solenoid **100** is energized to operate injector **94**.

To energize solenoid **100**, a signal generator **102**, which nominally may be considered as a normally open switch, provides a negative voltage pulse during each cycle of the engine. This pulse is differentiated by a capacitor **104** into a negative going voltage spike which is delivered to the base **106** of a transistor **108**. Transistor **108** thus ceases to conduct, and the voltage at its collector **110** increases to render a transistor **112** conductive. The voltage at the collector **114** of transistor **112** then drops and an amplifying transistor **116** stops conducting. The voltage at the collector **118** of transistor **116** is thereby increased, and solenoid **100** is energized to operate injector **94**.

As transistor **112** starts conducting, current passes through a primary winding **120**. Primary winding **120** is coupled, through a core **122** positioned by a pressure transducer **124**, with a secondary winding **126**. As current changes in primary winding **120**, a voltage is induced in secondary winding **126** which biases base **106** of transistor **108** in a negative direction and holds transistor **108** in a nonconductive state. Over a period of time the rate of change of current in primary winding **120** drops, and the voltage induced in secondary winding **126** reduces sufficiently to render transistor **108** conductive and terminate energization of solenoid **100**.

In order to control the duration of time solenoid **100** is energized, unit **92** may control the impedance in the circuit of either primary winding **120** or secondary winding **126**. Thus unit **92** could be a potentiometer **92***a* which, together with resistors **128**, **130** and **132**, controls the current supplied to primary winding **120**. Unit **92** also could be a switch **92***b* which adds a small resistor **134** to the resistors **136**, **138**, and **140** controlling the bias voltage on secondary winding **126**.

As shown in FIG. **9**, pressure transducer **124** is responsive to the absolute pressure in induction passages **14** below throttles **16**. It will be appreciated that the induction manifold pressure varies with movement of throttles **16** and with changes in engine load. In addition, as exhaust gas recirculation valve **36** opens and exhaust gas is recirculated to induction passages **14**, the absolute pressure in induction passages **14** increases. Manifold absolute pressure transducer **124** then moves core **122** in to increase the inductance between windings **120** and **126** and lengthen the time that solenoid **100** is energized. To compensate for this, the resistance of potentiometer **92***a* is increased as control valve **36** opens; this reduces the current flow through primary winding **120** to shorten the time that solenoid **100** is energized. Alternatively, switch **92***b* closes and small resistor **134** permits an increase in the bias voltage on secondary winding **126**; thus a shorter period of time is required to render transistor **108** conductive and terminate energization of solenoid **100**.

From the foregoing it will be appreciated that this invention provides a cam mechanism for controlling exhaust gas recirculation which simplifies visualization and calculation of the position of the control valve, and further, that this invention provides a fail-safe operating mechanism in which the throttles are permitted to close even if the control valve or its cam mechanism were to remain open.

I claim:

1. In an internal combustion engine having an induction passage for airflow to the engine, a throttle disposed in said induction passage and rotatable between closed and open positions for controlling airflow therethrough, an exhaust passage for exhaust gas flow from the engine, and an exhaust gas recirculation passage extending from said exhaust passage to said induction passage for recirculating exhaust gas to said induction passage: a control valve mounted on a rotatable shaft in said exhaust gas recirculation passage and controlling exhaust gas flow therethrough, and means for operating said control valve comprising a valve lever secured to said shaft and having a cam follower portion, a cam member having a straight slot formed therein, support means extending through said slot to support said member for linear movement thereof, said member further having a cam surface along one edge thereof including a first valve closed portion, a first valve moving ramp, a peak valve opening portion, a second valve moving ramp, and a second valve closed portion, means biasing said cam follower portion of said control valve lever against said cam surface whereby said control valve is positioned in accordance with the position of said cam member, and linking means connecting said cam member and said throttle for concomitant movement, whereby said cam member is moved linearly as said throttle is rotated from closed to open position and said cam follower portion of said control valve lever successively contacts said first valve closed portion and said control valve remains closed, said first valve moving ramp and said control valve opens, said peak valve opening portion and said control valve remains open, said second valve moving ramp and said control valve closes, and said second valve closed portion and said control valve remains closed, thereby proportioning the flow of exhaust gas recirculated to said induction passage to the flow of air through said induction passage.

2. In an internal combustion engine having an induction passage for airflow to the engine, a throttle mounted on a rotatable throttle shaft in said induction passage controlling airflow therethrough, an exhaust passage for exhaust gas flow from the engine, an exhaust gas recirculation passage extending from said exhaust passage to said induction passage for recirculating exhaust gas to said induction passage, and a control valve mounted on a rotatable valve shaft in said exhaust gas recirculation passage controlling exhaust gas flow therethrough: means for operating said control valve comprising a cam, operating mechanism providing a one-way drive connection between said cam and said valve shaft whereby movement of said cam in a valve opening direction may move said valve shaft in a valve opening direction and whereby said cam may move in a valve closing direction while said control valve remains stationary, means biasing said valve shaft in a valve closing direction, linking means providing a one-way drive connection between said throttle shaft and said cam whereby movement of said throttle shaft in a throttle opening direction may move said cam in a valve-opening direction and whereby said throttle shaft may move in a throttle-closing direction while said cam remains stationary, and means biasing said cam in a valve-closing direction.