

Aug. 25, 1959

R. W. SUTTON
FUEL SUPPLY SYSTEM

2,900,967

Filed March 11, 1957

4 Sheets-Sheet 1

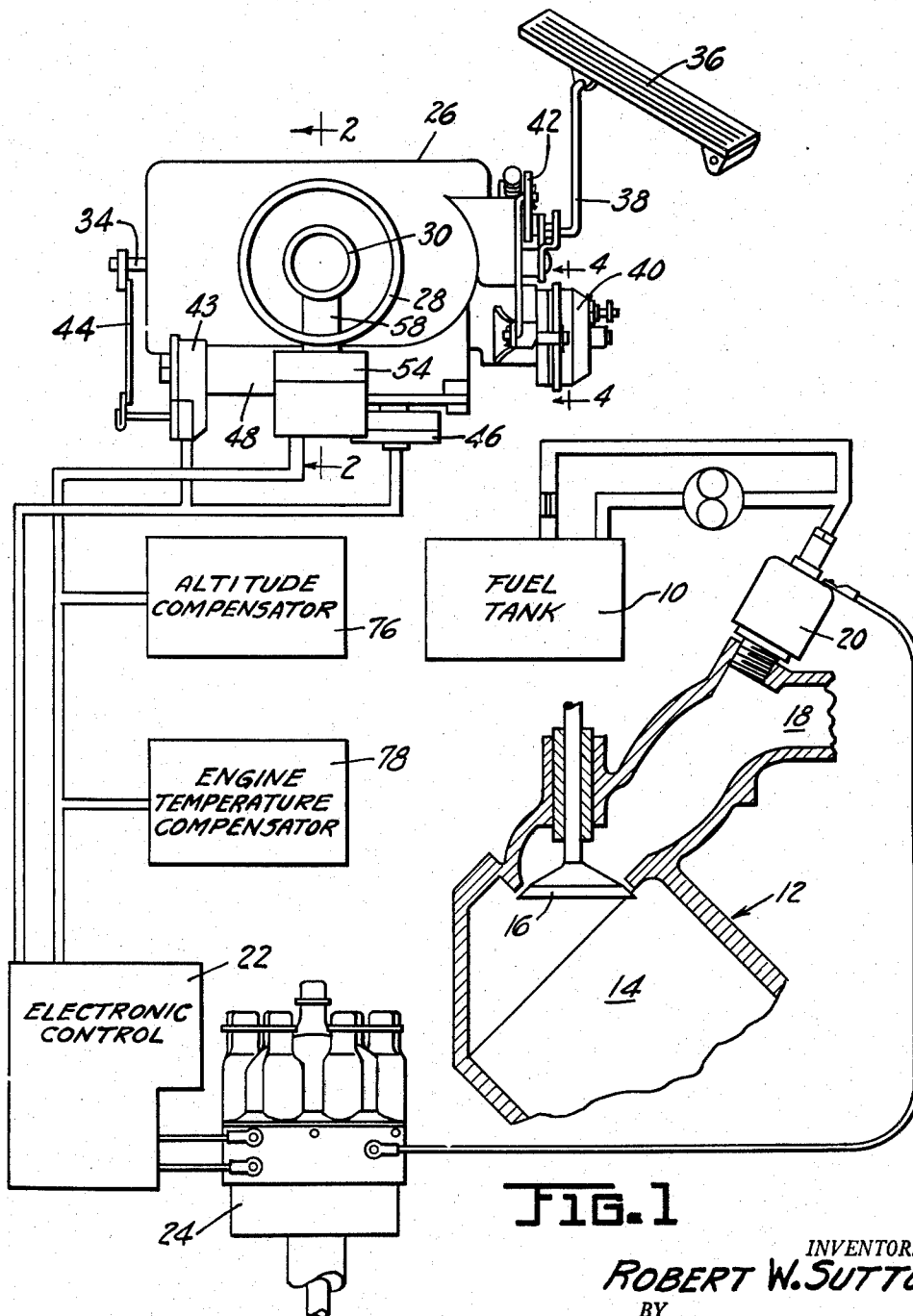


FIG. 1

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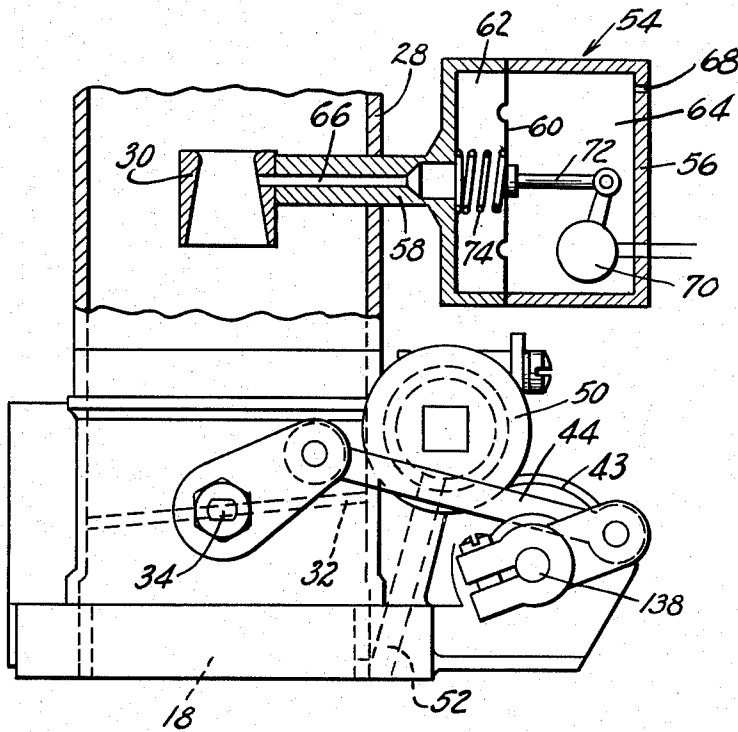
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4 Sheets-Sheet 2



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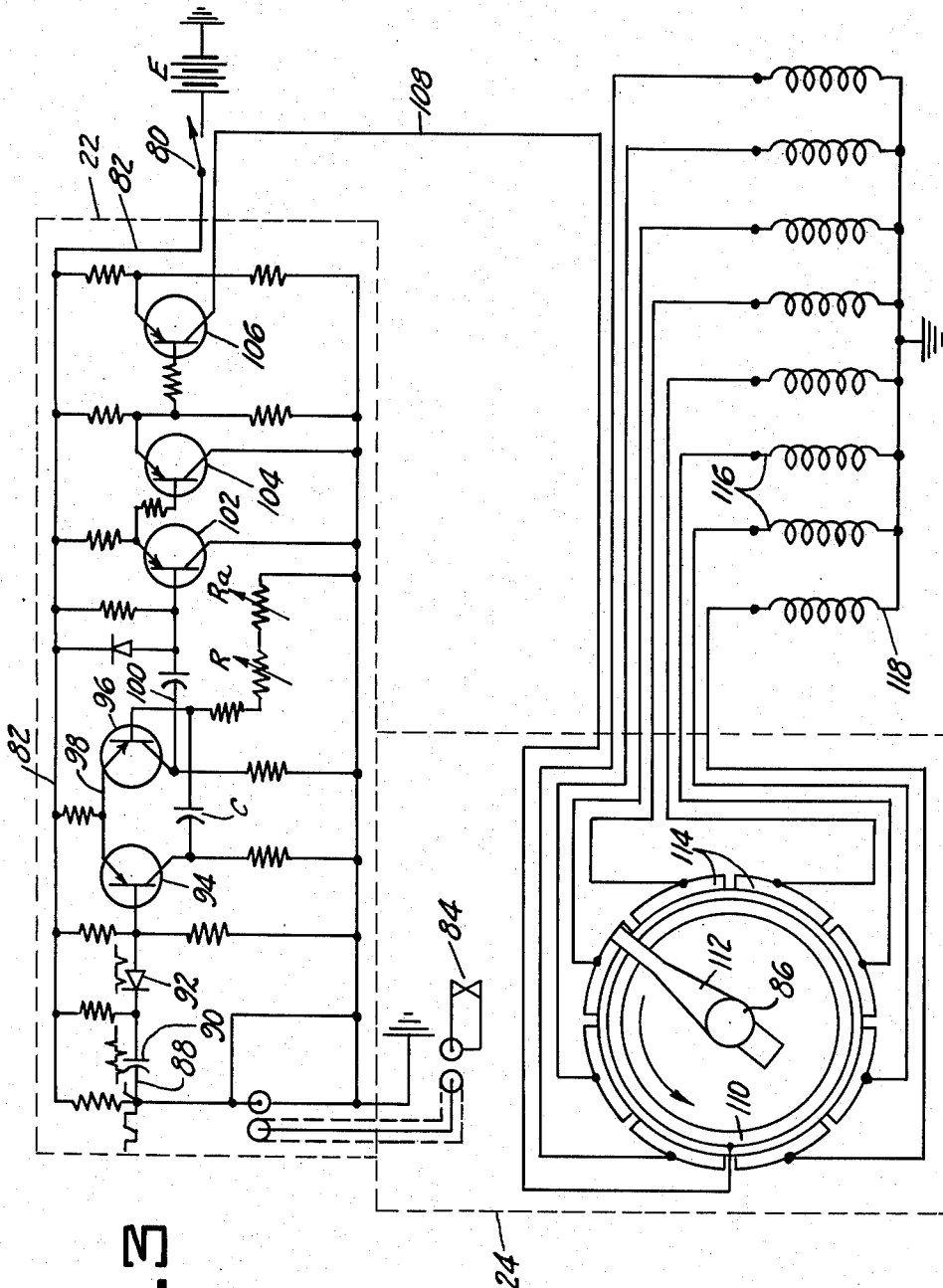
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

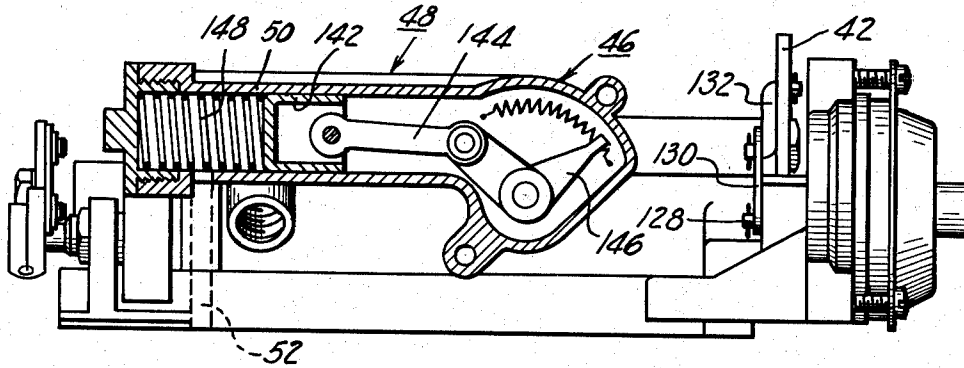


FIG. 6

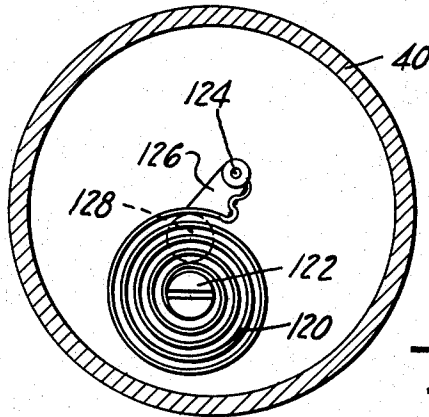


FIG. 4

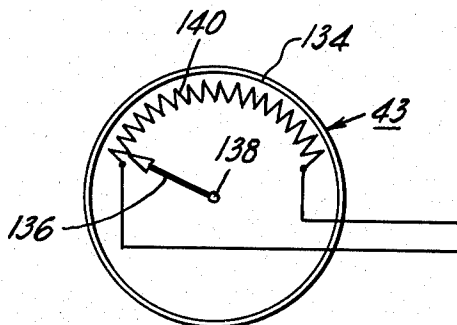


FIG. 5

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2,900,967

FUEL SUPPLY SYSTEM

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Application March 11, 1957, Serial No. 645,045

7 Claims. (Cl. 123—119)

The present invention relates generally to fuel supply systems for internal combustion engines and more particularly to a control for such systems to compensate for volumetric changes in air flow to the engine.

In my copending application U.S. Serial No. 637,852, Sutton et al., filed February 4, 1957, assigned to the assignee of the present invention, there is shown a fuel supply system wherein the quantity of fuel supplied to an engine is controlled by varying the time duration of fuel injection. As disclosed and claimed in said copending application the time duration of fuel injection may be controlled as a function of induction passage pressure, atmospheric pressure, throttle position, and ambient and engine temperatures.

The above mentioned functions fail, however, to provide compensation for volumetric changes in air flow to the engine. At wide open throttle induction passage pressure tends to remain substantially constant, whereas engine speed and air flow to the engine may vary widely depending on load and other conditions.

The present invention has as an object the provision of a control for modulating the time duration of fuel injection as a function of air flow to the engine.

Other objects and advantages will be readily apparent from the following detailed description taken in connection with the appended drawings in which:

Figure 1 is a schematic view of a fuel supply system embodying the present invention;

Figure 2 is a view partly in section taken along line 2—2 of Figure 1;

Figure 3 is a circuit diagram of the electronic control shown in Figure 1;

Figure 4 is a sectional view taken along line 4—4 of Figure 1;

Figure 5 is an end view with the cover removed of the throttle actuated potentiometer shown in Figure 1; and

Figure 6 is a front view partially in section of the throttle body shown in Figure 1.

Referring now to the drawings and more particularly to Figure 1, numeral 10 designates a source of fuel, 12 an engine, 14 a cylinder or combustion chamber, 16 an inlet valve, 18 an air induction passage and 20 a fuel injector mounted to discharge fuel into said passage. The engine 12 may be provided with a plurality of combustion chambers and the number of injectors 20 may conveniently correspond with the number of combustion chambers although the proportion of injectors to combustion chambers may be increased or decreased as desired.

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The injectors 20 are arranged to be actuated by an electronic control 22 which is triggered by and connected to an appropriate injector 20 by a trigger-distributor unit 24. Unit 24 triggers or energizes the electronic control 22 periodically as a function of engine speed. The electronic control 22 once energized remains energized for a time duration controlled as a function of certain engine operating conditions to be described. The output of the electronic control 22 is connected to an appropriate injector 20 through the distributor portion of unit 24. In systems having a plurality of fuel injectors 20 the distributor unit 24 successively connects them to the electronic control 22 as a function of engine speed. Each of the injectors 20 contains a valve energizable by a solenoid or other electrical means and when connected to the electronic control the valve opens for the time duration that the electronic control remains energized.

Air flow through the induction passage 18 is regulated by a throttle body unit 26 which is provided with an airhorn 28 containing a small venturi 30. Throttle body 26 is also provided with a pair of throttle valves, one of which is shown at 32 mounted on a shaft 34 journaled in the side walls of the body unit 26. The throttle valves 32 are arranged for actuation by an accelerator pedal 36 through the linkage 38. An engine temperature control 40 is operatively connected to a fast idle cam 42 which is disposed to engage linkage 38 to provide fast idle control of the throttle valves. A potentiometer 43 is secured to the throttle body unit 26 for actuation by throttle valves 32 through shaft 34 and linkage 44. Also disposed on throttle body unit 26 is potentiometer 46 which is arranged for actuation by an induction passage pressure responsive element 48. Element 48 includes a cylinder 50 connected to the induction passage 18 downstream of the throttle through a conduit 52. A movable wall or piston 142, as best seen in Figure 6, is disposed in cylinder 50 and connected by an appropriate linkage with potentiometer 46. Potentiometer 43 and 46 are connected by appropriate leads to the electronic control unit 22.

An air flow responsive unit 54 which is secured to a sidewall of the airhorn by a tubular member 58 an extension of which supports the small venturi 30 in the center of the airhorn. A diaphragm or movable wall 60 is marginally clamped by the walls of housing 56 which are secured together by suitable means (not shown). Diaphragm 60 divides the interior of housing 56 into chambers 62 and 64. Chamber 62 is connected to the throat of venturi through a conduit 66. Chamber 64 is in communication with the atmosphere through a port 68 formed in an end wall of housing 56. A potentiometer 70 is mounted in chamber 64 and connected to diaphragm 60 through a linkage 72. A spring 74 is disposed in chamber 62 to urge diaphragm 60 in a direction to move potentiometer 70 toward one of its extreme positions. The pressure in chamber 62 is substantially the same as the pressure in the throat of venturi 30 which varies as a function of the rate of air flow through the induction passage 18. Diaphragm 60 is responsive to the pressure differential between venturi pressure in chamber 62 and atmospheric pressure at 64 and is movable in response thereto in opposition to calibrated spring 74 to move potentiometer 70 toward the other of its extreme posi-

tions. Potentiometer 70 is connected by appropriate leads to the electronic control 22. Potentiometers responsive to ambient air pressure and engine temperature are shown schematically at 76 and 78 respectively and are also connected to the electronic control 22 by appropriate leads.

Referring now to Figure 3 which illustrates the circuit of electronic control 22, the potentiometers 43, 46, 76 and 78 have been collectively designated as R. The air flow responsive potentiometer 70 has been designated R_A . As shown in Figure 3 a source of electrical power E is connected through a switch 80 and conductor 82 with a switch 84 located in the trigger-distributor unit 24. Switch 84 is mounted for actuation by a shaft 86 which is adapted to be driven as a function of engine speed. When switch 84 is opened and closed a series of square shaped pulses are formed in conductor 88. The square shaped pulses are transformed by condenser 90 and rectifier 92 into a series of negative voltage spikes which are effective to trigger a normally non-conducting transistor 94 which together with transistor 96 forms a multi-vibrator unit 98. The multi-vibrator unit 98 produces a pulse in conductor 100, the width of which is a function of the time constant $(R+R_A)C$. Conductor 100 is connected through an amplifier including cascaded transistors 102, 104 and 106, by means of conductor 108 to commutator 110 in the distributor portion of trigger-distributor unit 24. A wiper arm 112 driven by shaft 86 is arranged to successively connect the commutator 110 with segmental contacts 114 which are respectively connected to solenoids 116 in the fuel injectors 20. The solenoids 116 are disposed to open fuel valves 118 in nozzles 20 when energized.

In operation, a fuel injection cycle is started by actuation of switch 84 by the engine driven shaft 86. The multi-vibrator 98 is energized by the switch 84 and discharges a pulse of electrical energy the width of which is controllable as a function of the time constant $(R+R_A)C$. The multi-vibrator thus controls the time duration of current flow in the conductor 100. The pulse of electrical energy from multi-vibrator 98 is amplified through transistors 102, 104, 106 and delivered to the distributor portion of trigger-distributor unit 24 for successive connection to appropriate solenoids as a function of engine speed. The solenoids are energized for a time duration dependent upon the output of the control 22. When energized the solenoids 116 are effective to open valves 118 and hold them open for the time duration of current flow through the solenoid. Fuel from source 10 will be discharged into the induction passage 18 through an injector nozzle for the time duration that a valve 118 remains open.

The air flow responsive unit 54 is arranged so that the spring 74 is effective to move potentiometer 70 to a point where R_A is substantially zero when the air flow through the induction passage 18 is substantially zero. As the air flow through the induction passage 18 increases the venturi suction increases and when a predetermined differential between the venturi pressure in 62 and atmospheric pressure in 64 is reached the diaphragm 60 will be moved in a direction to increase the resistance R_A of potentiometer 70. Thus the air flow responsive unit 54 has the effect through the change of R_A of modulating or modifying the time constant of multi-vibrator 98 to vary the time duration of current flow through circuit of control 22.

As best shown in Figure 4, engine temperature control 40 comprises a thermostat 120 having one end fixed to a stud 122 and the other end hooked over a pin 124 which is secured to a lever 126. Lever 126 is connected to fast idle cam 42 by means of shaft 128, lever 130 and rod 132.

As best shown in Figure 5, potentiometer 43 comprises a housing 134 having a wiper arm 136 mounted therein on a shaft 138 for engagement with winding 140. Shaft

138 is connected to throttle shaft 34 by means of linkage 44.

As best seen in Figure 6, potentiometer 46 is mounted on throttle body 26 for actuation by an induction passage pressure responsive device 48. Device 48 includes a cylinder 50 having a piston 142 reciprocally mounted therein. A linkage 144 connects piston 142 with the wiper arm 146 of potentiometer 46. A spring 148 mounted in cylinder 50 urges piston 142 toward one of its extreme positions. Cylinder 50 is connected to the induction passage posterior to the throttles by means of conduit 52 whereby piston 142 is movable in response to changes in induction passage pressure toward the other of its extreme positions.

While a preferred embodiment of my invention has been described it will be readily apparent to those skilled in the art that various changes and arrangements can be made to change the objects of the invention without departing from the spirit thereof.

I claim:

1. In a fuel supply system for a multi-cylinder internal combustion engine having an induction passage, a nozzle for each of said cylinders, a valve in each of said nozzles, a solenoid for each of said valves energizable to open said valves, an electrical circuit for said solenoids, a switch in said circuit adapted to be periodically closed as a function of engine speed, a device in said circuit adapted to be activated when said switch is closed to control the time duration of current flow in said circuit, and means operatively connected to said device and responsive to pressures varying as a function of the rate of air flow through said passage for modifying said control.

2. In a fuel supply system for a multi-cylinder internal combustion engine having an induction passage, a nozzle for each of said cylinders, a valve in each of said nozzles, a solenoid for each of said valves energizable to open said valves, an electrical circuit for said solenoids, a switch in said circuit adapted to be periodically closed as a function of engine speed, a device in said circuit adapted to be activated when said switch is closed to control the time duration of current flow in said circuit, means responsive to pressures varying as a function of the rate of air flow through said passage for varying said time duration and means driven as a function of engine speed to successively connect said device to said solenoids.

3. A device for supplying a fuel mixture to an engine comprising an air passage, a source of fuel under pressure, a connection from said source to said air passage, a valve in said connection, control means for opening said valve, means for activating said control means as a function of engine speed, means responsive to the pressure in said passage for regulating the time duration that said control means remains activated to hold said valve open, and means responsive to pressures varying as a function of the rate of air flow through said passage operatively connected to said control means for modifying the time duration that said control means remains activated.

4. A device for supplying a fuel mixture to an engine comprising an air passage, a source of fuel under pressure, a connection from said source to said air passage, a valve in said connection, electrical means for opening said valve, a timing device operatively connected to said means for controlling the time duration of valve opening, and means responsive to changes in air flow through said passage for regulating said device to vary said time duration.

5. A device for supplying a fuel mixture to an engine comprising an air passage with a venturi therein, a source of fuel under pressure, a connection from said source to said air passage, a valve in said connection, means periodically actuated as a function of engine speed for opening said valve for a controlled time duration independent of the frequency of actuation, and means responsive to venturi pressure operatively connected to said first mentioned means for modulating said time duration.

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6. A device for supplying fuel to an engine having an induction passage comprising a venturi in said passage, a source of fuel under pressure, a connection from said source to said passage, a valve in said connection, electrical means energizable to open said valve, an electric power source, means for connecting said power source to said electrical means for a controllable time duration, and means responsive to venturi pressure for varying said time duration.

7. A device for supplying fuel to an engine comprising an air passage, a venturi in said passage, a source of fuel under pressure, a connection from said source to said passage, a valve in said connection, means energizable by an electric current to open said valve, a source of electrical power, a circuit connecting said power source with

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said means, an element in said circuit effective to control the time duration of current flow therethrough, and a movable wall responsive to venturi pressure and operatively connected to said element for varying said time duration.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,900,967

August 25, 1959

Robert W. Sutton

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 22, for "products" read -- produces --; column 4, line 59, for "prssure" read -- pressure --.

Signed and sealed this 19th day of April 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents