

[54] FUEL VAPOR AND AIR MIXING DEVICE
WITH FUEL-AIR RATIO LIMITING MEANS

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124 B, 127 R

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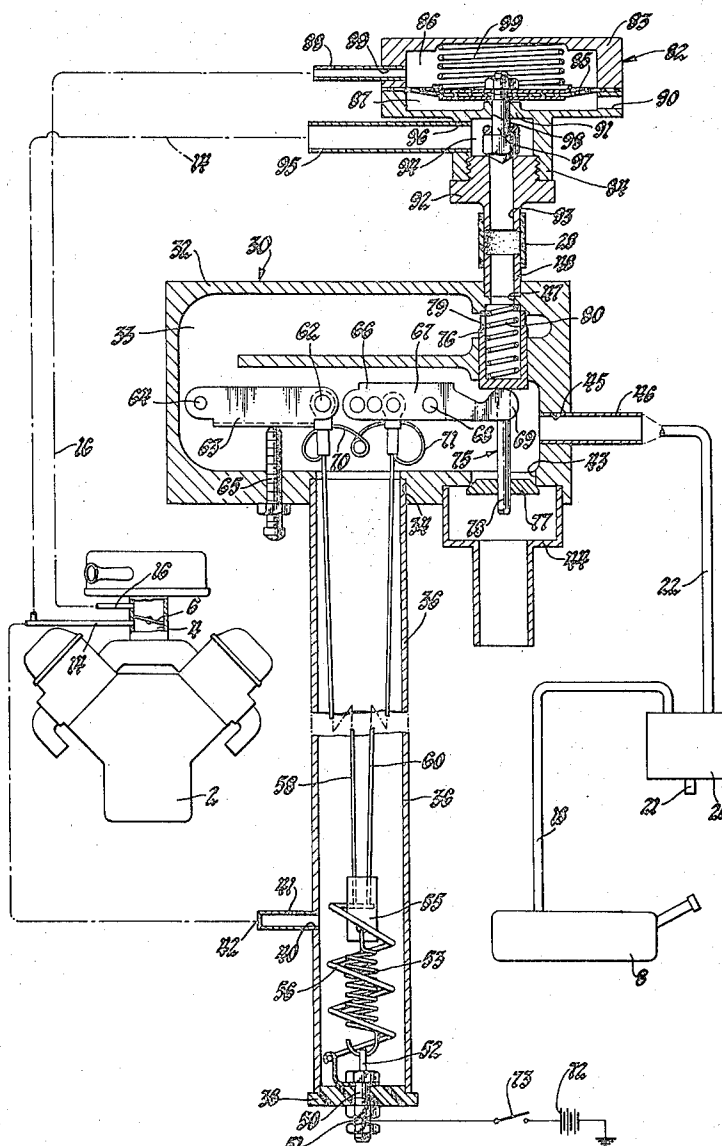
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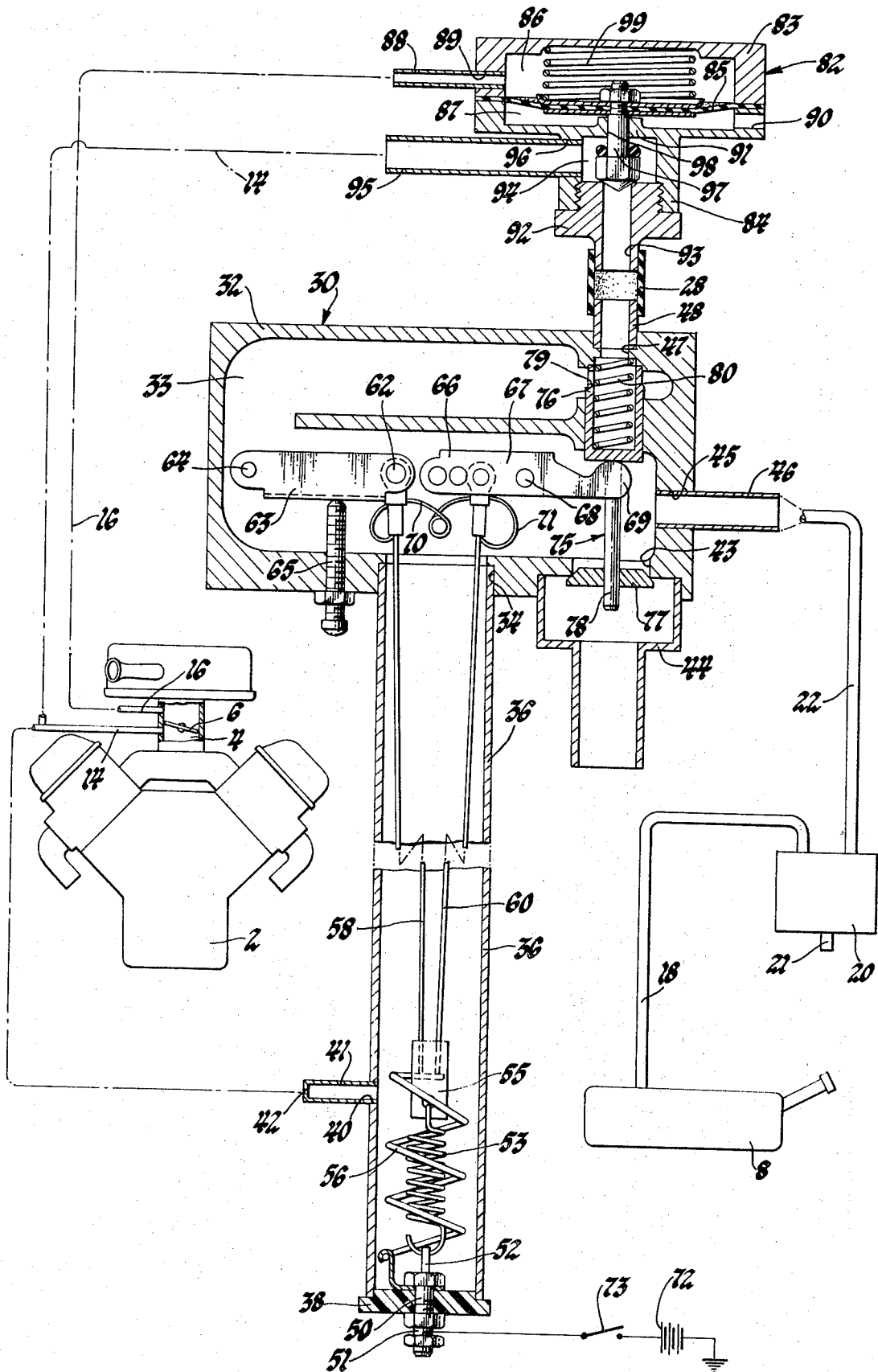
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[57] ABSTRACT

In a fuel-vapor and air mixing device for an internal combustion engine, a purge stream of gases from a fuel vapor collection device passes through a chamber, wherein a sample of the purge stream is passed over a fuel-air ratio measuring device comprising a pair of parallel wires, one of which is coated with an oxidation catalyst and the other of which is not. The wires are connected to actuate a valve from a source of air upstream from the wires in the chamber when the fuel-air ratio exceeds a reference level to admit additional air to and thus limit the fuel-air ratio of the purge stream.

4 Claims, 1 Drawing Figure





FUEL VAPOR AND AIR MIXING DEVICE WITH FUEL-AIR RATIO LIMITING MEANS

BACKGROUND OF THE INVENTION

In order that undesirable exhaust emissions from internal combustion engines be minimized, it is desirable to maintain strict control of the fuel-air ratio in the gases supplied to the engine for combustion. It is particularly important to avoid mixtures that are too rich in fuel, since these tend to be incompletely oxidized in the engine.

A problem of particular concern in limiting fuel richness is the generation of fuel vapor in the engine fuel storage and supply system. Since combustible fuel is quite volatile, a substantial amount of vapor can form in the fuel tank or elsewhere in the fuel system, particularly in warm weather or climates. Most engine fuel systems include means to store this vapor to prevent its release to the atmosphere and to feed it to the engine for combustion when the engine is operating. The fuel-air ratio of the vapor thus supplied to the engine must be carefully controlled to avoid undesirable richness.

Systems proposed in the past have diluted the fuel vapor-air ratio of the mixture by the addition of air in an amount proportional to the amount of mixture or the fuel tank vapor pressure. Such systems may not be adequate to control the mixture richness with the accuracy required by today's stringent vehicle emission standards.

SUMMARY OF THE INVENTION

It is an object of this invention to supply fuel vapor and air to an internal combustion engine with an accurately limited fuel-air ratio. This is accomplished by directing a sample portion of the vapor on its way to the engine through a chamber containing two parallel wires. One of these wires is coated with an oxidation catalyst, and the other is uncoated. There is a valved air inlet in the chamber upstream from the wires; and the wires are mechanically connected to allow this valve to open when a rich fuel mixture causes the catalyst coated wire to heat and lengthen relative to the uncoated wire. The device thus comprises a closed loop control system to limit fuel-air ratio of the vapor passing through it.

Further details and advantages of the invention are described in the following description of a preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The FIGURE shows a fuel-air mixing device according to the invention. An internal combustion engine 2 has a fuel system including an air induction passage 4 with an air induction valve 6 therein. Fuel for the engine 2 is stored in a tank 8.

The operating fuel-air mixture for the engine 2 can be obtained in a carburetor, to which fuel would be supplied from tank 8 by a pump and conduit not shown. In this system, the induction passage 4 would include the portion of the carburetor throat below the venturi and the common passage of the intake manifold; and the induction valve 6 would be the throttle valve, controlling the flow of fuel-air mixture to the engine 2.

Alternatively, the fuel supply system for engine 2 may be of the fuel injection type, in which the induction passage 4 and induction valve 6 control the flow

of air from the air cleaner 12 to the engine 2, and the fuel is delivered from tank 8 and injected directly into the cylinders of engine 2 by fuel injection means not shown.

Regardless of the type of fuel mixing used, however, connecting with the induction passage 4 are a vacuum conduit 14, which is open to the induction passage 4 below the induction valve 6, generally in the intake manifold, and a ported vacuum conduit 16, which is open to the induction passage 4 adjacent the induction valve 6 so that it opens above the valve 6 when that valve is closed but below valve 6 when that valve opens. The vacuum conduit 14 is that used for the positive crankcase ventilation system on engines so equipped.

In addition, a fuel vapor conduit 18 connects the highest point in the fuel tank 8 with the carbon canister 20. The carbon canister 20 is a well known device that contains activated carbon, which has the ability to adsorb fuel vapor evaporating from the liquid fuel in the tank 8 through the conduit 18. Normally there is another conduit provided from the carbon canister 20 which connects with the vacuum or ported vacuum conduit. The carbon canister 20 has an air inlet 21, through which a purge stream of air is drawn for desorbing the fuel vapor from the activated carbon and carrying the fuel vapor into the engine for combustion when the engine is operating.

However, this invention inserts a fuel-air ratio limiter 30 between the carbon canister 20 and the induction passage 4. The limiter 30 comprises a housing 32 with an opening 34 into which is pressed a long tube 36 closed by a cap 38. The tube 36 has, near its lower end, an opening 40, into which is pressed a tube 41 with a restricted orifice 42 of approximately 0.037 inch diameter the tube 41 being connected to a branch of the vacuum conduit 14. The housing 32 contains additional openings 43, 45 and 47, into which are pressed tubes 44, 46 and 48, respectively. The tube 44 is open to the atmosphere and serves as an air inlet to the chamber 33 formed by the housing 32 and tube 36. If necessary, it could have an air cleaner in it or attached thereto, but this is omitted in the FIGURE for simplicity. The tube 46 is sealingly connected to a conduit 22 from the carbon canister 20 and forms a fuel vapor inlet for the chamber 33. The tube 48 serves as an outlet for the chamber 33.

The cap 38, made of an electrically insulating material, has a bolt 50 projecting therethrough, the bolt 50 forming on the outside of the tube 36 an electrical terminal 51 and on the inside of the tube 36 an eyelet 52. The eyelet 52 serves as an anchor for one end of a spring 53, the other end of which is attached to a movable member 55. The movable member 55 has embedded therein one end of a connecting wire 56 which is insulation covered and coiled loosely around the spring 53 with its other end in electrical contact with the bolt 50. Also having ends embedded in the movable member 55, in electrical contact with the connecting wire 56, are two uninsulated conducting wires 58 and 60 which extend essentially parallel to one another through the tube 36. The wires 58 and 60 are made of a resistance wire material such as Chromel-A, which exhibits substantial heating during current conduction and substantial changes in length with changes in temperature. Wire 60, in addition, is coated with an oxidation catalyst such as platinum.

The other end of wire 58 is connected to the free end 62 of lever 63 which is free to pivot around a pivoting end 64 in chamber 33. A bolt 65 forms an adjustable stop for the lever 63 which allows the wire 58 to be pulled taut by the spring 53.

The other end of wire 60 is connected to a lever 67 near one end 66 thereof. The lever 67 is free to pivot about a pivot pin 68 near its center; and its other end 69 is engaged with a valve mechanism to be described below. Connecting wires 70 and 71 connect the lever ends of wires 58 and 60 electrically to the housing 32, which is grounded. A source of electric current, such as battery 72, has one end grounded and the other connectible to the terminal 51 through switch 73, which could be a vehicle ignition switch. Although, in this embodiment, the wires 58 and 60 are connected to the current source in parallel, they could be connected in series.

A valve mechanism comprises a cylindrical valve element 76 engageable with opening 47 and poppet valve element 77 engageable with opening 43 and fixed by a stem 78 with respect to the cylindrical valve element 76 for co-movement therewith. The cylindrical valve element 76 contains an opening 79 therethrough of approximately 0.06 inch diameter and contains therein a compressed spring 80 which biases the valve assembly 75 downward as shown in the FIGURE to open the outlet opening 47 and the air inlet opening 43. The lever 67, when the wire 60 is pulled taut, tends to move the valve assembly 75 upward as shown in the FIGURE to fully close the air inlet 43 and restrict flow through the outlet 47 to that obtainable through the opening 79 in member 76.

In this embodiment, the fuel-air ratio limiter 30 is shown operating in conjunction with a purge shut-off valve 82. The purge shut-off valve 82 is included to prevent the flow of combustible vapor to the engine when the engine is idling or decelerating, at which times extra fuel might cause the engine to run faster than desired. It comprises upper and lower housing members 83 and 84 with a flexible diaphragm 85 between them forming first and second chambers 86 and 87. A tube 88 pressed in an opening 89 in the upper housing member 83 connects the first chamber with the ported vacuum conduit 16. A port 90 in the lower housing member 84 opens the second chamber 87 to the atmosphere.

An internal wall 91 and an inlet member 92 with an inlet opening 93 therein form a third chamber 94. A tube 95 pressed in an opening 96 in lower housing member 84 connects the third chamber with a branch of the vacuum conduit 14. A valve member 97, attached to the diaphragm 85 and projecting through an opening 98 in the internal wall 91, is biased downward by a spring 99 above the diaphragm 85 in the first chamber 86 to close the inlet opening 93. A short connecting tube 28 between the tube 48 and inlet member 92 serves to connect the outlet opening 47 of the fuel-air ratio limiter 30 with the inlet opening 93 of the purge shut-off valve 82.

The operation of the device will now be described. Assuming that the vehicle upon which the device is installed has been sitting for some time without being operated, fuel vapor evaporating in tank 8 has collected in the carbon canister 20. Provided that the capacity of carbon canister 20 has not been exceeded, there will be no flow of fuel vapor from the carbon canister 20 to the fuel-air ratio limiter 30 while the engine is not operat-

ing. The adjustable stop 65 has been adjusted so that the wire 58 is slightly slack with all or nearly all of the tension produced by spring 53 being maintained in wire 60 biasing the valve assembly 75 to its fully closed position.

A vehicle operator closes the ignition switch 73 and starts the engine 2. The closure of the ignition switch 73 allows current to flow from the battery 72 through terminal 51, bolt 50, connecting wire 56, wires 58 and 60, connecting wires 70 and 71 and housing 32 to ground. The electric current is sufficient to heat the wires 58 and 60 to a temperature at which the catalyst coating on wire 60 becomes actuated: for platinum, 300° F. The wires 58 and 60 increase in length as they increase in temperature. However, since the temperatures of wires 58 and 60 rise at similar rates to approximately equal levels, their lengths increase by like amounts and spring 53 contracts to maintain tension. Thus wire 60 continues to bear most or all of the spring tension; and the valve assembly 75 is maintained in its closed position.

With the engine 2 idling, the induction valve 6 has not opened beyond the ported vacuum conduit 16; and the valve member 97 in the purge shut-off valve 82 prevents any vacuum from being applied from the vacuum conduit 14, through the purge shut-off valve 82, to the carbon canister 20. There is some flow of fuel vapor and air from the carbon canister 20 to the vacuum conduit 14 by way of tubes 36 and 41; but this flow is restricted by orifice 42 to a very low rate, so that the engine 2 will not be appreciably affected thereby.

When the operator opens the induction valve 6 to accelerate the engine 2, vacuum is applied through the ported vacuum conduit 16 to chamber 86 of the purge shut-off valve 82. The pressure differential across diaphragm 85 thus overcomes the force of spring 99 and actuates the valve member 97 to open the inlet 93. The reduced pressure in the vacuum conduit 14 is now communicated through the opening 79 in cylindrical valve element 76 to the carbon canister 20. Since opening 79 is significantly larger than the restricted orifice 42, the flow rate of the purge stream from carbon canister 20 is now greatly increased. This purge stream is drawn through conduit 22, tube 46, chamber 33, opening 79, tube 48, inlet opening 93, chamber 94, tube 95, vacuum conduit 14 and induction passage 4 into the engine 2. Since, when the induction valve 6 is open, fuel and air are being consumed by the engine 2 at a high rate, the amount introduced from the carbon canister through the vacuum conduit 14, provided the mixture is not too rich, should have no appreciable effect upon engine performance.

A portion of the purge stream from the carbon canister 20 continues to be drawn through tube 36, opening 40, tube 41 and restricted orifice 42 to the vacuum conduit 14. The comparatively small volume of this separate restricted purge stream insures that the temperatures of the wires 58 and 60 do not fall below the activation temperature of the catalytic coating of wire 60, as they might if the wires were exposed to the full flow of the purge stream. As the sample mixture is drawn over the wires 58 and 60, the catalytic coating on wire 60 causes oxidation of the fuel vapor. This oxidation releases heat on the surface of wire 60, which causes the temperature of wire 60 to increase relative to that of wire 58. Wire 60 now begins to lengthen with respect to wire 58; and this has the effect, as the mov-

able member 55 moves downward, of applying tension to wire 58. When the full tension of spring 53 is applied to wire 58, the movable member 55 can move no further downward. The fuel-air ratio sufficient to cause this constitutes a reference level, adjustable by the stop 65, above which the purge stream will be diluted with air. Further lengthening of the wire 60 now permits the lever 67 to pivot and the spring 80 to move the valve assembly 75 downward to an extent determined by the length of wire 60. As the valve assembly 75 moves downward, the plug valve element 77 opens air inlet 43 to decrease the richness of the mixture passing through chamber 33; and cylindrical valve element 76 pulls away from opening 47 to allow a greater volume of gases to flow therethrough so that the purge rate from carbon canister 20 will not be reduced. Since the new leaner mixture flowing through chamber 33 is also drawn through tube 36 over wires 58 and 60, the temperature and length of wire 60 will be reduced thereby and the device will tend toward an equilibrium in which the richness of the mixture supplied to the vacuum conduit 14 to the engine 2 will be slightly greater than the richness level that just causes the valve assembly 75 to open, but greatly reduced from the richness of the purge stream from the carbon canister 20. When the richness of the mixture of the carbon canister 20 eventually declines, the shortening of wire 60 causes the valve assembly 75 to move again to its closed position; and the device thus continually monitors the richness of the fuel-air mixture from carbon canister 20, using as a signal the length of wire 60 relative to the length of wire 58; and acts automatically to limit it.

With the preferred embodiment of my invention thus described, it should be noted that other embodiments will occur to those skilled in the art. My invention should therefore be limited only by the claims which follow.

I claim:

1. A device for controlling the fuel-air ratio of a fuel vapor-air mixture for supply to the induction passage of an internal combustion engine, said device comprising, in combination: a housing defining a chamber, said housing having an inlet for communication with a source of fuel vapor-air mixture of variable fuel-air ratio and main and restricted outlets for communication with said induction passage, whereby a stream of fuel vapor-air mixture is drawn through said chamber from said mixture inlet to said outlets, said housing further having an inlet for communication with a source of air for the admission of air into said chamber to reduce the fuel-air ratio of said mixture; an air valve in said air inlet for controlling the flow of air therethrough, said air valve having a closed position in which the flow of air through said air inlet is prevented; a valve positioning mechanism adapted to move said air valve to and from its closed position, said valve positioning mechanism including spring means for biasing said air valve away from its closed position; first and second substantially parallel electrically conducting wires in said chamber, one end of each of said wires being connected to a movable member, said first wire having its other end fixed with respect to said housing, said second wire being coated with an oxidation catalyst and having its other end connected to said valve positioning mechanism so that tension in said second wire is applied in opposition to the bias of said spring means, said movable member being biased away from

said wires in a direction parallel to said wires so as to produce tension in at least one of said wires, said movable member normally producing in said second wire tension sufficient to hold said air valve in its closed position; said wires being connectible to a source of electric current for heating said wires to the activation temperature of said oxidation catalyst, said wires being positioned downstream from said air inlet in the path of only that portion of the stream of mixture flowing to said restricted outlet, whereby an increase in fuel-air ratio causes said second wire to increase in temperature and length relative to said first wire and thus allows said valve positioning mechanism to open said air valve to limit said fuel-air ratio.

2. The device of claim 1 in which the valve positioning mechanism provides for air valve movement in each direction proportional to the change in length of said second wire.

3. A device for controlling the fuel-air ratio of a fuel vapor-air mixture for supply to the induction passage of an internal combustion engine, said device comprising, in combination: a housing defining a chamber, said housing having an inlet for communication with a source of fuel vapor-air mixture of variable fuel-air ratio, and main and restricted outlets for communication with said induction passage, whereby a stream of fuel vapor-air mixture is drawn through said chamber from said mixture inlet to said outlets, said housing further having an inlet for communication with a source of air for the admission of air into said chamber to reduce the fuel-air ratio of said mixture; an air valve in said air inlet for controlling the flow of air therethrough, said air valve having a closed position in which the flow of air through said air inlet is prevented; a mixture valve in said main outlet for controlling the flow of mixture therethrough, said mixture valve having a closed position in which the flow of mixture through said main outlet is restricted to a substantially lesser degree than the flow of mixture through said restricted outlet; a valve positioning mechanism adapted to move said air and mixture valves to and from their closed positions, said valve positioning mechanism linking said air and mixture valves for co-movement and including spring means for biasing said air and mixture valves away from their closed positions; first and second substantially parallel electrically conducting wires in said chamber, said first wire having one end thereof fixed with respect to said housing, said second wire having a coating of an oxidation catalyst material and having an end adjacent the fixed end of said first wire connected to said valve positioning mechanism so that tension produced in the second wire is applied in opposition to the bias of said spring means; a movable member in said chamber, said movable member being adapted to hold the other ends of said first and second wires and being biased away from said wires in a direction parallel to said wires so as to produce tension in at least one of said wires, said movable member normally producing in said second wire tension sufficient to hold said air and mixture valves in their closed position; said wires being connectible to a source of electric current for heating said wires to the activation temperature of said oxidation catalyst material, said wires being positioned downstream from said air inlet in the path of only that portion of the stream of mixture flowing to said restricted outlet, whereby an increase in fuel-air ratio causes said second wire to increase in temperature and length rela-

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tive to said first wire and thus allows said valve positioning mechanism to open said air and mixture valves whereby said fuel-air ratio is limited with no concurrent decrease in the flow rate of gases from said source of fuel vapor-air mixture.

4. A device for controlling the fuel-air ratio of a fuel vapor-air mixture for supply to the induction passage of an internal combustion engine, said device comprising, in combination:

a housing defining a chamber, said housing having an inlet for communication with a source of fuel vapor-air mixture of variable fuel-air ratio and an outlet for communication with said induction passage, whereby a stream of fuel vapor-air mixture is drawn through said chamber from said mixture inlet to said outlet, said housing further having an inlet for communication with a source of air for the admission of air into said chamber to reduce the

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fuel vapor-air ration of said mixture; an air valve in said air inlet for controlling the flow of air there-through, said air valve having a normally closed position in which the flow of air through said inlet is prevented; a valve positioning mechanism responsive to a fuel-air ratio signal to open said air inlet when said fuel-air ratio exceeds a reference level, whereby said fuel-air ratio is limited; and means in said chamber downstream from said air valve for generating said fuel-air ratio signal, said means comprising a pair of wires, one of said wires being coated with an oxidizing catalyst and the other not being so coated, said wires being so connected to said valve positioning mechanism that said valve positioning mechanism is responsive to the length of said catalyst coated wire relative to said other wire.

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