PATENTED FEB 29 1972 3,645,244

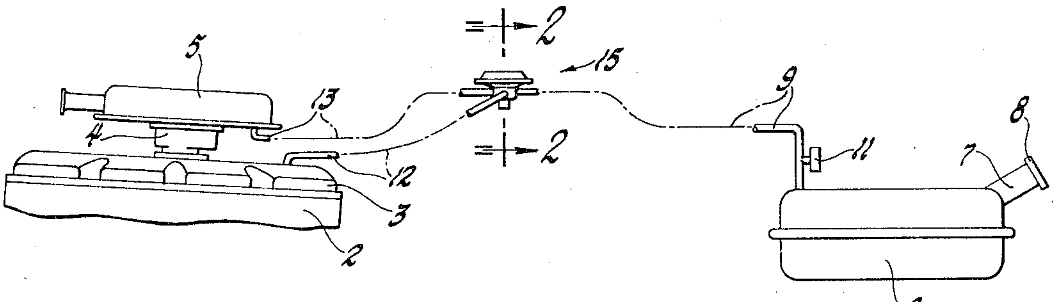

Fig.1

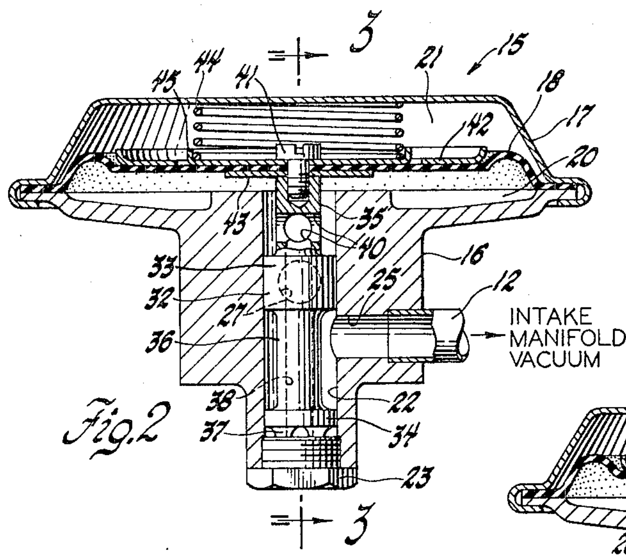

Fig.2

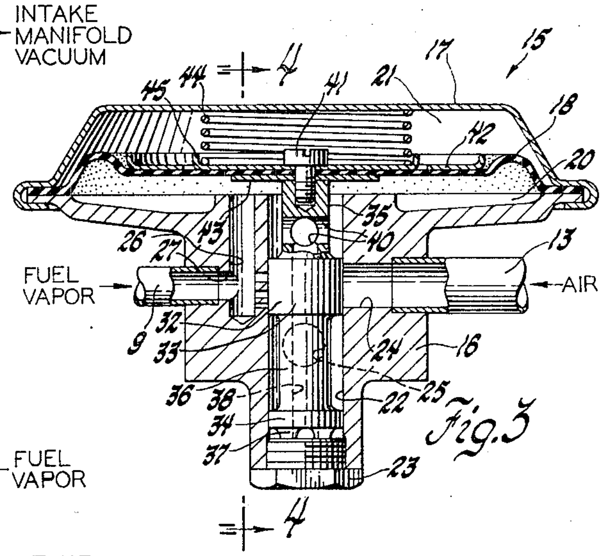

Fig.3

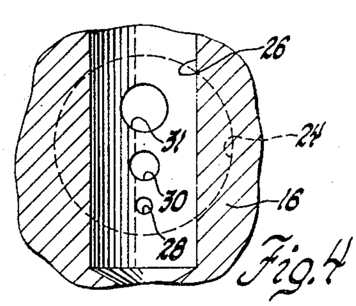

Fig.4

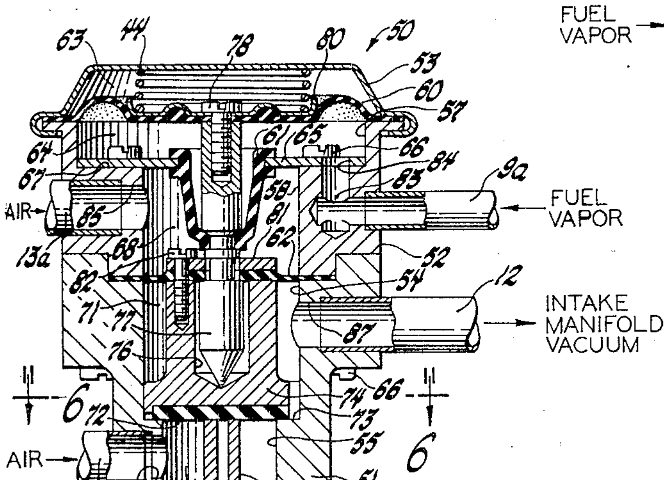

Fig.5

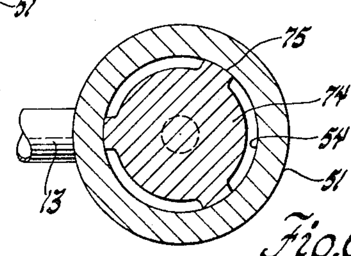

Fig.6

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[54] **SYSTEM FOR MIXING AIR WITH FUEL TANK VAPOR**

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[73] Assignee: **General Motors Corporation,** Detroit, Mich.

[22] Filed: **Mar. 31, 1971**

[21] Appl. No.: **129,938**

Related U.S. Application Data

[63] Continuation of Ser. No. 2,050, Jan. 12, 1970, abandoned.

[52] **U.S. Cl.** **123/136,** 123/120, 123/119

[51] **Int. Cl.** **F02d 19/00**

[58] **Field of Search** 123/119, 136, 120, 121

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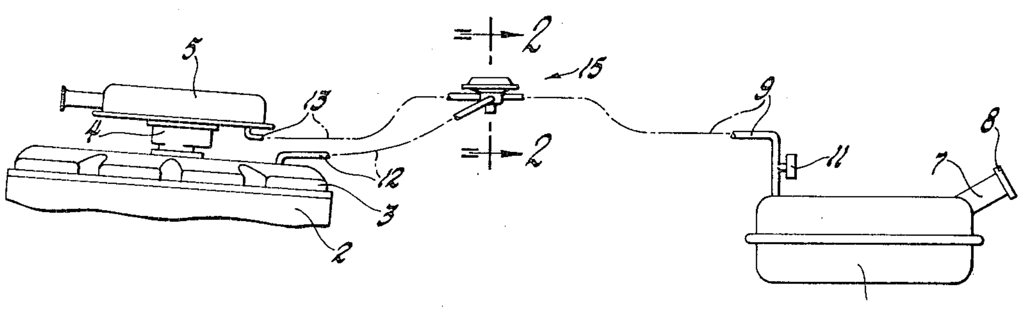
[57] **ABSTRACT**

A system for mixing air with fuel tank vapor in which fuel vapor stored in a fuel tank is used to open a diaphragm operated mixing valve to meter fuel vapor and air into the intake manifold of an internal combustion engine.

10 Claims, 6 Drawing Figures



SYSTEM FOR MIXING AIR WITH FUEL TANK VAPOR

This application is a continuation of application, Ser. No. 2,050 filed Jan. 12, 1970 now abandoned.

This invention relates to a system for mixing air with fuel tank vapors and, more particularly, to a system utilizing a fuel vapor actuated mixing valve to bleed air and fuel tank vapors together to form a combustible air-fuel mixture which is then inducted into the intake manifold of an internal combustion engine.

It is well known that vapors and gases emitted from internal combustion engines contribute to the present day problem of air pollution. Accordingly, much attention has been directed to controlling the polluting emissions from internal combustion engines. Many corrective devices have been proposed and utilized to control the most obvious source of emission, that is, the emission of fumes from the exhaust system and crank case of the engine. Another source of hydrocarbon emission from an internal combustion engine is the fuel vapor escaping from the fuel system. In particular, gas vapor may escape from the external vents of both the fuel tank and the carburetor float bowl, either while driving or while at rest. It has been estimated that of these uncontrolled fuel evaporation losses, the loss from the fuel tank accounts for from 50 to approximately 75 percent of this total. In an effort to reduce the fuel vapor emission from the fuel system, various evaporative loss control devices have been proposed and utilized whereby the fuel vapors are contained and then delivered to the intake manifold of the engine while it is in operation for consumption therein. This approach has worked successfully to help reduce the emission of fuel vapors directly from the fuel system but, under certain engine operating conditions, this feedback of the fuel vapors for consumption in the engine has affected engine operation or has increased the exhaust emission of unburned hydrocarbon or both.

It is, therefore, the principal object of this invention to improve a system for mixing air with fuel tank vapors whereby air and fuel vapors are mixed together to form a suitable air-fuel mixture which is then inducted into the intake manifold of an internal combustion engine.

Another object of this invention is to improve a system for mixing air with fuel tank vapors in which a mixing valve is used to bleed fuel tank vapors and air together to form a suitable air-fuel mixture which is then inducted into the intake manifold of an internal combustion engine without affecting the operation of the engine or causing an increase in exhaust emission.

Still another object of this invention is to improve a system for mixing air with fuel tank vapors whereby tank fuel vapor pressure opens a diaphragm-operated valve which meters fuel vapor and air at a suitable air-fuel ratio into the intake manifold of an internal combustion engine.

These and other objects of the invention are obtained by means of a system for mixing air with fuel tank vapors for an internal combustion engine wherein fuel vapor, stored in a nonvented fuel tank, is delivered to a mixing valve having a fuel vapor pressure-controlled diaphragm-operated valve which is used to meter fuel vapor and air into the intake manifold of the engine during operation of the engine.

For a better understanding of the invention, as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic view of a portion of an engine fuel system incorporating a system for mixing fuel tank vapors with air in accordance with the invention;

FIG. 2 is an enlarged sectional view of the mixing valve of the system taken along line 2—2 of FIG. 1;

FIG. 3 is a sectional view of the mixing valve taken along line 3—3 of FIG. 2;

FIG. 4 is an enlarged sectional view of the metering orifices of the mixing valve taken along line 4—4 of FIG. 3;

FIG. 5 is a sectional view of an alternate form of mixing valve for the system of FIG. 1; and,

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5.

Referring now to FIG. 1, an internal combustion engine 2 has an intake manifold 3 on which a carburetor 4 and an air cleaner 5 are mounted. A supply of fuel, such as gasoline, for the engine 2 is contained in a fuel tank 6 from which liquid fuel is delivered through a suitable conduit and fuel pump, not shown, to the carburetor 4. Fuel tank 6, provided with a filler neck 7 closed by a nonvented cap 8, normally contains a quantity of liquid fuel with the space above the liquid fuel containing fuel vapor. A conduit 9 is connected to the fuel tank in position to receive fuel vapor from the tank and the conduit 9 is provided with a vacuum relief valve 11.

Fuel vapor from fuel tank 6 is delivered through conduit 9 to a vapor carburetor or mixing valve, generally designated 15, in a manner to be described whereby the fuel vapor is mixed with air and delivered by conduit 12 to the intake manifold 3 of the engine for combustion therein. The mixing valve 15 is connected in any suitable way to a source of clean air and is herein shown as being connected by conduit 13 to the air cleaner 5.

Referring now to FIGS. 2, 3 and 4, there is illustrated a preferred embodiment of a fuel vapor carburetor or mixing valve 15 which includes a valve body 16 and cap 17 which together make up a casing divided into two chambers by a flexible diaphragm 18 shown in this embodiment, sealingly clamped at its outer periphery between the body 16 and cap 17. The two chambers formed therein are a first or a lower chamber 20, and a second or upper chamber 21. The body 16 is provided with a centrally bored passage 22 closed at the bottom thereof by a screwplug 23 engaged into the threaded end of the bored passage. Extending radially from the bored passage 22 and in communication therewith are an air inlet passage 24 and an air-fuel discharge passage 25, connected to conduits 13 and 12, respectively. As shown in FIGS. 2 and 3, the air inlet passage 24 is spaced above the air-fuel discharge passage 25 for a purpose to be described.

A second bored passage 26 extends parallel to passage 22, as seen in FIG. 3, and interconnects with a fuel vapor inlet passage 27 connected by conduit 9 to the fuel tank and connected to passage 22 by means of spaced-apart metering orifices 28, 30 and 31 of progressively larger sizes starting from the bottom metering orifice 28. Passages 22 and 26, at their upper ends, are in communication with the chamber 20.

A spool valve 32 is movably positioned in passage 22 and is provided with a central land 33 and a bottom land 34, each having an outside diameter such as to be in slideable engagement within the passage, an upper reduced portion 35, a reduced portion 36 between lands 33 and 34, and a slotted reduced bottom portion 37. A central passage 38 extends from the bottom of the spool valve upward to interconnect with through radial passages 40 normal to each other in the upper reduced portion 35. The spool valve 32 is also provided at its upper end with a threaded bore to receive a screw 41 which extends through an apertured diaphragm retainer 42, a suitable aperture in the diaphragm 18 and apertured bottom plate 43 whereby the spool valve is secured to the diaphragm for movement therewith.

The diaphragm 18, and therefore the spool valve 32 are normally biased downward to the valve closed position shown in FIGS. 2 and 3 by a coiled spring 44 which is engaged at one end against the cap 17 and at the other end against the retainer 42, the spring being aligned thereon by engagement with lanced and turned up tabs 45 formed in the retainer 42. This spring is a relatively light spring having a force equal to the desired valve opening fuel vapor pressure as affected by the effective diaphragm area.

In this bottom or closed position of the spool valve 32, the central land 33 thereof is positioned to block off the metering orifices 28, 30 and 31, and also to block off the air inlet passage 25. However, as the fuel vapor pressure in the fuel tank increases, the fuel vapor entering through the passages 27 and 26 into the lower chamber 20 will move the diaphragm 18 upward against the biasing action of the spring 44 to move the spool valve 32 upward whereby this land will progressively uncover one or more of the metering orifices **28**, **30** and **31**, depending on the fuel vapor pressure, and the air inlet passage **25**. If this occurs due to a buildup of fuel vapor pressure in the fuel tank **6** when the engine is not running, fuel vapor discharged through these metering orifices will be vented to the atmosphere through air inlet passage **24** and the conduit **12**, the mixing valve **15** thus serving as a pressure relief valve for the fuel tank.

During engine operation, when the fuel vapor pressure is sufficient to open the diaphragm **18** operated spool valve **32**, the thus opened valve will allow fuel vapors to bleed into the passage **22** between the lands **33** and **34** of the spool valve **32** where intake manifold vacuum will draw it through the air-fuel discharge passage **25** and conduit **12** into the intake manifold **3** of the engine **2**. Since there is a reduced pressure in the intake manifold during engine operation and since the metering orifices are sized to suitably control the fuel vapor flow rates, outside air from the air cleaner **5** is simultaneously drawn through the air intake passage **24** resulting in a flow of air into the passage **22** wherein it is mixed with the fuel vapor to form a suitable air-fuel mixture before this mixture of fuel vapor and air are drawn into the intake manifold of the engine. By properly correlating the size of the metering orifices **28**, **30** and **31** and the internal diameter of the air inlet passage **24** for a specific engine application, a suitable combustible air-fuel mixture can be formed in the mixing valve **15** so that, as this additional air-fuel mixture is introduced into the engine, it will not affect the overall performance of the engine or have an adverse affect on exhaust emission.

An alternate embodiment of a mixing valve, generally designated **50**, suitable for use in the system of FIG. **1**, is illustrated in FIGS. **5** and **6**. This mixing valve **50** includes a lower valve body **51**, an upper valve body **52** and cap **53**. The lower valve body **51** is counterbored to provide an upper annular bore **54**, an intermediate bore **55** and a lower reduced diameter bore **56**, while the upper body **52** is counterbored to provide an enlarged top bore **57** and a bottom bore **58**, the latter having an internal diameter substantially equal to that of bore **54** in the lower valve body **51**. Lower valve body **51**, upper valve body **52** and cap **53** together make up a valve casing divided into a number of chambers by a plurality of diaphragms **60**, **61** and **62**.

Diaphragm **60**, which is the main control diaphragm, is sealingly clamped between cap **53** and the upper portion of the upper valve body **52** to form therewith an upper chamber **63** and a lower pressure control chamber **64**, the bottom wall of the latter being defined by an annular apertured plate **65**, secured as by screws **66** to the internal shoulder **67** of the upper valve body **52**, and by the cup-shaped diaphragm **61** having its annular grooved outer flange engaged in the apertured opening of plate **65**.

Diaphragm **62** is sealingly clamped between the lower valve body **51** and the upper valve body **52**, which are secured together as by screws **66** to form with the bores therein an intermediate chamber **66** to form with the bores therein an intermediate chamber **68** and a bottom chamber further divided into an air inlet chamber **70** and a mixing chamber **71** between which communication is normally blocked by a valve **72** adapted to seat on the internal shoulder **73** of the lower valve body. Valve **72**, made of rubber, is bonded to the bottom of valve plunger **74**, which is provided at the lower portion thereof with spaced-apart radial lands **75** slideably received in bore **54** of the lower valve body **51**.

The upper portion of the valve plunger **74** is provided with a bore **76** to receive the lower end of an actuating plunger **77** therein, the valve plunger and actuating plunger being operatively connected together, as described hereinafter, to form a valve plunger. The actuating plunger **77** is provided at its upper end with a threaded bore to receive a screw **78** which extends through an apertured diaphragm retainer **80**, and a suitable aperture in the diaphragm **60** whereby it is secured to the diaphragm for movement therewith.

The diaphragm **60** and, therefore, the actuating plunger **77** are normally biased downward to the valve closed position shown in FIG. **5** by a coiled spring **44** which is engaged at one end against the cap **53** and at the other end against the retainer **80**. The actuating plunger **77** is provided centrally thereof with an annular groove received within the central aperture of diaphragm **61**, and a second annular groove which is slidably received in the central aperture of diaphragm **62** and retainer **81**, the diaphragm **62** and retainer **81** being secured to the top of valve plunger **74** by screws **82**. As shown in FIG. **5**, the diaphragm **62** and retainer **81** are snapped between the shoulders of the actuating plunger **77** formed by the lower annular groove therein so that axial movement of the actuating plunger **77** will effect corresponding movement of the plunger **74**.

Operation of this mixing valve is effected by the introduction of fuel vapor from the fuel tank **6** via branch conduit **9*a*** of conduit **9** which is in communication with a right-angle passage **83** in the upper valve body **52**, the latter being in communication with the lower chamber **64** by means of a aperture **84** in plate **65** positioned in alignment therewith. Air, for a purpose to be described hereinafter, is introduced by a secondary branch **13*a*** of conduit **13** and passage **85** in the upper valve body into the intermediate chamber **68**. The main branch of conduit **13** is in communication with air inlet chamber **70** via passage **86** in the lower valve body **51**. The mixing chamber **71** is in communication with the intake manifold **3** via passage **87** and conduit **12**. Positioned in the lower bore **56** of the lower valve body **51** is the main branch of conduit **9** which is connected to a metering orifice tube **88**, also positioned therein, the top of metering orifice tube **88** being positioned within the air inlet chamber **70** to abut against valve **72** when the valve is seated against the internal shoulder **73** of the lower valve body.

Thus from the bottom or the closed position of the valve, as shown in FIG. **5**, the spring **44** forces the actuating plunger **77** downward into engagement with the valve plunger **74** to force valve **72** into closed engagement with the valve plunger **74** to force valve **72** into closed engagement shoulder **73** and the top of the metering orifice tube **88** to block off the flow of clean air and fuel vapor into intermediate chamber **71**. Fuel vapor is, however, free to discharge through branch conduit **9*a***, passage **83** and aperture **84** into chamber **64** and, as the fuel vapor pressure increases sufficiently, it will move diaphragm **60** upward against the biasing action of spring **44**. As this occurs, actuator plunger **77** will move upward to in turn move the valve plunger **74** upward through its connection with diaphragm **62** and retainer **81** to lift the valve **72** off the shoulder **73** and off the end of the metering orifice tube **88**.

If this occurs, due to a buildup of fuel vapor pressure in the fuel tank **6** when the engine is not running, fuel vapor discharged through the metering orifice tube **88** will be vented to the atmosphere through passage **86** and conduit **13** for discharge to the atmosphere. The mixing valve **50** thus serves as a pressure relief valve for the fuel tank when the engine is not in operation.

During engine operation, when the fuel vapor pressure is sufficient to open the diaphragm **60** operated valve assembly, the thus opened valve will allow fuel vapors to bleed from the metering orifice tube **88** into chamber **71** where intake manifold vacuum will draw it through the passage **87** and conduit **12** into the intake manifold **3** of the engine **2**. Since there is a reduced pressure in the intake manifold during engine operation and, since the internal diameter of the metering orifice tube **88** is of a suitable size to control fuel vapor flow rates, outside air from the air cleaner **5** is simultaneously drawn through the air intake passage **86** resulting in a flow of air into the chamber **70** and then into chamber **71** wherein it is mixed with the fuel vapor bleed from the metering orifice to **88** to form an air-fuel vapor mixture which is then drawn into the intake manifold of the engine. By properly sizing the internal diameter of the metering orifice tube for a given engine application, a suitable combustible air-fuel mixture can be formed in the chamber 71 so that as this additional air-fuel mixture is introduced into the engine, and consumed therein, it will not affect the overall performance of the engine or have an adverse affect on exhaust emission.

Both the mixing valve 15 and the mixing valve 50 are designed so that opening of the respective valves of these units will not allow the engine manifold vacuum to overcome fuel vapor tank pressure and thus, to pull the valve shut which would result in "hunting" or chatter of the valve. To prevent this from occuring, the mixing valve 50 has separate chambers, a seen in FIG. 5, to eliminate any possibilities of engine manifold vacuum reaching the operating diaphragm 60. In the embodiment of the mixing valve 15, as shown in FIGS. 2 and 3, this "hunting" or chatter of the valve is prevented by the disclosed fuel vapor air and engine manifold connector arrangement, as seen in FIG. 3. The clean air connector, that is, passage 24 acts as a vacuum breaker upon movement of the spool valve 32 since a portion of this passage is uncovered by the central land thereof before the bottom metering orifice 28 is uncovered thereby.

What is claimed is:

1. A fuel vapor recovery system for an internal combustion engine having an intake manifold and a fuel reservoir, an air-fuel vapor mixing valve including a valve housing having passage means therein and a valve movable in said passage means between an open position and a closed position, valve operating means including a pressure responsive diaphragm in said housing to form a chamber therein, means operatively connecting said diaphragm and said valve whereby said valve may be positioned by said diaphragm, fuel vapor conduit means in communication with said fuel tank and with said chamber, metering orifice means connected to said fuel vapor conduit means and with said passage means, an air conduit means in communication with said passage means and with a source of atmospheric air, and conduit means in communication with said passage means and with said intake manifold, said metering orifice means and said air conduit means being operatively connected to said passage means in position whereby said valve when in said closed position will block flow of air and fuel vapor to said conduit means.

2. A fuel vapor recovery system according to claim 1 wherein said diaphragm in said housing forms a second chamber therein, spring means in said second chamber in operative relation to said diaphragm to normally bias said valve to said closed position.

3. A fuel vapor recovery system according to claim 2 wherein said metering orifice means includes a plurality of metering orifices of progressively larger diameters positioned so that as said valve moves from said closed position to said open position, said valve will sequentially unblock said metering orifices of progressively larger diameters.

4. A fuel vapor recovery system according to claim 2 wherein said valve is a spool valve having spaced apart upper and lower lands slideably journaled in said passage means and having a reduced portion between said upper and lower lands forming with said passage means a mixing chamber in communication with said conduit means, said metering orifice means and said air conduit means normally being blocked from the communication with said passage means by said upper land.

5. A fuel vapor recovery system according to claim 1 wherein said air-fuel vapor mixing valve further includes at least a second diaphragm forming with said diaphragm said chamber and with said valve housing an air chamber and second air conduit means in communication with said air chamber and with a source of atmospheric air, said valve extending through said second diaphragm in sealing engagement therewith.

6. A fuel vapor recovery system according to claim 1 wherein said air-fuel vapor mixing valve further includes a second diaphragm and a third diaphragm forming with said valve and said passage means an air chamber and a mixing chamber, second air conduit means in communication with said air chamber and with a source of atmospheric air, said conduit means being in communication with said passage means into said mixing chamber, said valve when moved from said closed position to said open position placing said air conduit means and said metering orifice means in communication with said mixing chamber.

7. A fuel vapor recovery system for an internal combustion engine having an air-fuel intake manifold and a fuel reservoir, a fuel vapor mixing valve including a valve housing having passage means therein and a valve movable in said passage means, pressure responsive diaphragm means in said housing operatively connected to said valve, fuel vapor conduit means in communication with said fuel tank and with one side of said diaphragm means whereby fuel vapor under pressure will effect movement of said diaphragm means for moving said valve, metering orifice means connected to said fuel vapor conduit means and with said passage means, an air conduit means in communication with said passage means and with a source of atmospheric air, and conduit means in communication with said passage means and with said intake manifold, said valve being movable from a first position blocking flow of air from said air conduit means and fuel vapor from said metering orifice means into said passage means to a second position to permit fluid communication between said metering orifice means, said air conduit means and said conduit means.

8. A fuel vapor recovery system for an internal combustion engine having an air-fuel intake manifold and a fuel reservoir, a fuel vapor mixing valve including a valve housing having passage means therein, a fuel vapor conduit means connected in fuel vapor flow relation to said fuel tank, metering orifice means in communication with said fuel vapor conduit means and with said passage means, an air conduit means in communication with said passage means and with a source of atmospheric air, conduit means in communication with said passage means and with said air-fuel intake manifold, a valve movable in said passage means between a closed position to block communication between said metering orifice means and said conduit means and between said air conduit means and said conduit means to an open position to permit fluid communication between said metering orifice means, said air conduit means and said conduit means, and differential pressure operating means connected to said valve to effect movement of said valve between said open position and said closed position, said differential pressure operating means including spring means to normally bias said valve to said closed position, and fuel vapor passage means in communication with said fuel vapor conduit means and said differential pressure operating means.

9. A fuel vapor recovery system according to claim 8 wherein said metering orifice means includes a plurality of metering orifices of progressively larger diameters and wherein said valve is a spool valve having spaced apart lands with a reduced portion therebetween forming with said passage means a mixing chamber in communication with said conduit means, one of said lands blocking communication of said metering orifices and said air conduit means with said mixing chamber when said valve is in said closed position.

10. A system for controlling loss of fuel vapor from a unit having a fuel reservoir and an internal combustion engine with an induction system, said system comprising a valve having a fuel vapor inlet connected to said fuel reservoir for receiving fuel vapor discharged from said reservoir, an air inlet, an outlet connected to said induction system for delivering a mixture of fuel vapor and air to said induction system, a valve mechanism disposed between said inlet and said outlet for controlling flow of fuel vapor and air from said inlets to said outlet, spring means biasing said valve mechanism to prevent flow of fuel vapor and air from said inlets to said outlet, and means responsive to the pressure in said fuel reservoir and connected to said valve mechanism whereby said valve mechanism is operated to control the rate of flow of fuel vapor and air from said inlets to said outlet in accordance with the pressure in said fuel reservoir.

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