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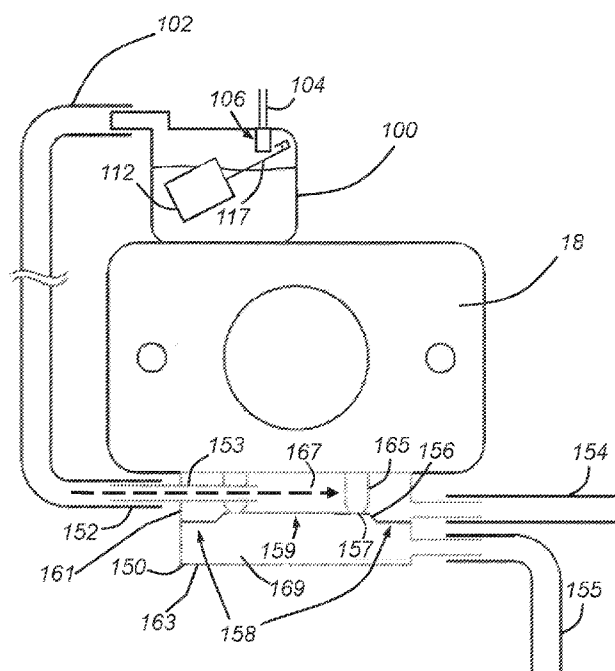


FIG. 4A

(57) Abstract: A charge forming device for a combustion engine includes a housing, a throttle valve and a vent valve. The housing has a throttle bore, an inlet chamber in which a supply of fuel is received, and a vent communicating with the inlet chamber. The throttle valve has a valve head movable relative to the throttle bore to control fluid flow through the throttle bore. The vent valve has a vent inlet in communication with the vent, a valve element having a closed position and an open position in which fluid may flow through the vent inlet. The vent valve has a pressure signal inlet in communication with a pressure source, and a vent outlet. A pressure signal is provided through the pressure signal inlet to cause the valve element to move between the open position and closed position to control fluid flow to and through the vent outlet.

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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CHARGE FORMING DEVICE WITH EVAPORATIVE EMISSION CONTROL**REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit of U.S. Provisional Application Serial No.
5 63/074,531 filed on September 4, 2020 the entire content of which is incorporated herein by
reference in its entirety.

TECHNICAL FIELD

The present disclosure relates generally to a charge forming device for supplying fuel
10 and air to an engine, and more specifically a charge forming device having a vent.

BACKGROUND

Fuel systems include a fuel tank from which liquid fuel is provided to a charge forming
device to provide a fuel and air mixture to a combustion engine. Fuel vapor can be generated
15 and exist within the fuel tank as well as within the charge forming device.

SUMMARY

In at least some implementations, a charge forming device for a combustion engine
includes a housing, a throttle valve and a vent valve. The housing has a throttle bore with an
20 inlet through which air is received, an inlet chamber in which a supply of fuel is received, and
a vent communicating with the inlet chamber. The throttle valve is carried by the housing and
has valve head movable relative to the throttle bore to control fluid flow through the throttle
bore. The vent valve is communicated with the vent, has a vent inlet in communication with
the vent, a valve element having a closed position in which fluid flow through the vent inlet is
25 inhibited or prevented and an open position in which fluid may flow through the vent inlet. The

vent valve has a pressure signal inlet in communication with a pressure source, and a vent outlet selectively communicated with the vent inlet when the valve element is in the open position. A pressure signal is provided to the valve element through the pressure signal inlet to cause the valve element to move between the open position and closed position to control fluid flow from
5 the vent inlet to and through the vent outlet.

In at least some implementations, the vent outlet communicates with an evaporative emissions canister configured to store fuel vapor. In at least some implementations, the vent outlet communicates with an air intake of the engine. This may reduce emissions from the system. In at least some implementations, the pressure source is an intake manifold of the
10 engine.

In at least some implementations, the valve element is a diaphragm. The vent valve may comprise an annular wall defining in part an inner chamber of the vent valve. An inner portion of the diaphragm may contact the annular wall in the closed position, the inner portion of the diaphragm may be spaced away from the annular wall in the open position.

15 In at least some implementations, an electrically actuated fuel metering valve is carried by the housing and has an inlet communicated with the inlet chamber to receive fuel from the inlet chamber and an outlet communicated with the throttle bore and through which fuel is supplied into the throttle bore.

In at least some implementations, an inlet valve is carried by the housing and has a
20 valve that controls the flow of fuel into the inlet chamber. The inlet valve may be coupled to a float received within the inlet chamber to actuate the inlet valve as a function of the level of fuel within the inlet chamber.

In at least some implementations, a second vent passage providing gaseous matter from a second source to the inlet chamber, wherein flow of gaseous matter from the inlet chamber
25 and from the second source is controlled by the vent valve. In at least some implementations,

the second source is a fuel tank.

In at least some implementations, a method of venting a charge forming device for a combustion engine, includes providing a housing having a throttle bore with an inlet through which air is received, an inlet chamber in which a supply of fuel is received, and a vent
5 communicating with the inlet chamber. The method also includes installing a throttle valve in the housing, the throttle valve having a valve head movable relative to the throttle bore to control fluid flow through the throttle bore, and communicating a vent valve with the vent passage via a vent inlet, the vent valve having a valve element, a pressure signal inlet in communication with a pressure source, and a vent outlet, the valve element having a closed position in which
10 fluid flow through the vent valve is inhibited or prevented and an open position in which fluid may flow through the vent valve. The method further includes biasing the valve element toward the closed position, and communicating a pressure signal to the valve element via the pressure signal inlet, thereby moving the valve element to the open position to permit fluid flow from the vent inlet to the vent outlet.

15 In at least some implementations, the method also includes communicating the vent outlet with an evaporative emissions canister configured to store fuel vapor. In at least some implementations, the method also includes communicating the vent outlet with an air intake of the engine.

In at least some implementations, the pressure source is an intake manifold of the
20 engine.

In at least some implementations, the valve element is a diaphragm.

In at least some implementations, the method also includes pulsing the pressure signal, thereby cycling the valve element between the open position and the closed position.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description of certain embodiments and best mode will be set forth with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a throttle body assembly with pressure responsive vent
5 valve;

FIG. 2 is another perspective view of the throttle body assembly;

FIG. 3 is a cross-sectional view of the throttle body assembly illustrating an inlet valve
and a fuel metering valve;

4A is a diagrammatic view of the throttle body assembly illustrating the pressure
10 responsive vent valve in a closed position;

FIG. 4B is a diagrammatic view of the throttle body assembly illustrating the pressure
responsive vent valve in an open position;

FIG. 5 is a diagrammatic view of a fuel system including a fuel tank, throttle body
assembly and an engine; and

15 FIG. 6 is a process flow diagram of an example method of venting a throttle body
assembly.

DETAILED DESCRIPTION

Referring in more detail to the drawings, FIGS. 1 - 3 illustrate a charge forming device
20 10 that provides a combustible fuel and air mixture to an internal combustion engine 12 (shown
schematically in FIG. 1) to support operation of the engine. The charge forming device 10 may
be utilized on a two or four-stroke internal combustion engine, and in at least some
implementations, includes a throttle body assembly 10 from which air and fuel are discharged
for delivery to the engine.

The assembly 10 includes a housing having a throttle body 18 that has a throttle bore 20 with an inlet (not shown) through which air is received into the throttle bore 20 and an outlet 24 connected or otherwise communicated with the engine (e.g., an intake manifold 26 thereof). Throttle body 18 may have any configuration that is convenient, including but not limited to the boost venturi configuration described further below. The inlet may receive air from an air filter, if desired, and that air may be mixed with fuel provided from a fuel metering valve 28 carried by or communicated with the throttle body 18. The intake manifold 26 generally communicates with a combustion chamber or piston cylinder of the engine during sequentially timed periods of a piston cycle. For a four-stroke engine application, as illustrated, the fluid may flow through an intake valve and directly into the piston cylinder. Alternatively, for a two-stroke engine application, typically air flows through the crankcase before entering the combustion chamber portion of the piston cylinder through a port in the cylinder wall which is opened intermittently by the reciprocating engine piston.

The throttle bore 20 may have any desired shape including (but not limited to) a constant diameter cylinder, or a venturi shape wherein the inlet leads to a tapered converging portion that leads to a reduced diameter throat that in turn leads to a tapered diverging portion that leads to the outlet 24. The converging portion may increase the velocity of air flowing into the throat and create or increase a pressure drop in the area of the throat. In at least some implementations, a secondary venturi, sometimes called a boost venturi 36 may be located within the throttle bore 20 whether the throttle bore 20 has a venturi shape or not. The boost venturi 36 may have any desired shape, and as shown in FIGS. 1 and 3, has a converging inlet portion 38 that leads to a reduced diameter intermediate throat 40 that leads to a diverging outlet 42. The boost venturi 36 may be coupled to the throttle body 18 within the throttle bore 20, and in some implementations, the throttle body may be cast from a suitable metal and the boost venturi 36 may be formed as part of the throttle body, in other words, from the same

piece of material cast as a feature of the throttle body when the remainder of the throttle body is formed. The boost venturi 36 may also be an insert coupled in any suitable manner to the throttle body 18 after the throttle body is formed. In the example shown, the boost venturi 36 includes a wall 44 that defines an inner passage 46 that is open at both its inlet 38 and outlet 42 to the throttle bore 20. A portion of the air that flows through the throttle body 18 flows into and through the boost venturi 36 which increases the velocity of that air and decreases the pressure thereof. The boost venturi 36 may have a center axis 48 (FIG. 3) that may be generally parallel to a center axis 50 (FIG. 3) of the throttle bore 20 and radially offset therefrom, or the boost venturi 36 may be oriented in any other suitable way.

Referring to FIG. 1, the air flow rate through the throttle bore 20 and into the engine is controlled at least in part by a throttle valve 52. In at least some implementations, the throttle valve 52 includes a head 54 which may include a flat plate disposed in the throttle bore 20 and coupled to a rotating throttle valve shaft 56. The shaft 56 extends through a shaft bore 58 formed in the throttle body 18 that intersects and may be generally perpendicular to the throttle bore 20. The throttle valve 52 may be driven or moved by an actuator 60 between an idle position wherein the head 54 substantially blocks air flow through the throttle bore 20 and a fully or wide open position wherein the head 54 provides the least restriction to air flow through the throttle bore 20. In one example, the actuator 60 may be an electrically driven motor 62 coupled to the throttle valve shaft 56 to rotate the shaft and thus rotate the valve head within the throttle bore 20. In another example, the actuator 60 may include a mechanical linkage, such as a lever attached to the throttle valve shaft 56 to which a Bowden wire may be connected to manually rotate the shaft 56 as desired and as is known in the art.

The fuel metering valve 28 (FIG. 3) may have an inlet 66 to which fuel is delivered, a valve element 68 (e.g., a valve head) that controls fuel flow rate and an outlet 70 downstream of the valve element 68. To control actuation and movement of the valve element 68, the fuel

metering valve 28 may include or be associated with an electrically driven actuator 72 such as (but not limited to) a solenoid. Among other things, the solenoid 72 may include an outer casing 74 received within a cavity 76 in the throttle body 18, a coil 78 wrapped around a bobbin 80 received within the casing 74, an electrical connector 82 arranged to be coupled to a power source to selectively energize the coil 78, and an armature 84 slidably received within the bobbin 80 for reciprocation between advanced and retracted positions. The valve element 68 may be carried by or otherwise moved by the armature 84 relative to a valve seat 86 that may be defined within one or both of the solenoid 72 and the throttle body 18. When the armature 84 is in its retracted position, the valve element 68 is removed or spaced from the valve seat 86 and fuel may flow through the valve seat. When the armature 84 is in its extended position, the valve element 68 may be closed against or bears on the valve seat 86 to inhibit or prevent fuel flow through the valve seat. The solenoid 72 may be constructed as set forth in U.S. Patent Application Serial No. 14/896,764. The inlet 68 may be centrally or generally coaxially located with the valve seat 86, and the outlet 70 may be radially outwardly spaced from the inlet and generally radially outwardly oriented. Of course, other metering valves, including but not limited to different solenoid valves or commercially available fuel injectors, may be used instead if desired in a particular application.

In the example shown, the valve seat 86 is defined within the cavity 76 of the throttle body 18 and may be defined by a feature of the throttle body or by a component inserted into and carried by the throttle body or the solenoid casing 74. Also, in the example shown the valve seat 86 is defined by a metering jet 88 carried by the throttle body 18. The jet 88 may be a separate body press-fit or otherwise installed into the cavity 76 and having a passage or orifice 90 through which fuel at the inlet 66 to the metering valve 28 flows before reaching the valve seat 86 and valve element 68. The flow area of passages downstream of the jet 88 may be greater in size than the minimum flow area of the jet so that the jet provides the maximum

restriction to fuel flow through the metering valve 28. Instead of or in addition to the jet 88, a passage of suitable size may be drilled or otherwise formed in the throttle body 18 to define a maximum restriction to fuel flow through the metering valve 28. Use of a jet 88 may facilitate use of a common throttle body design with multiple engines or in different engine applications wherein different fuel flow rates may be needed. To achieve the different flow rates, different jets having orifices with different effective flow areas may be inserted into the throttle bodies while the remainder of the throttle body may be the same. Also, different diameter passages may be formed in the throttle body 18 in addition to or instead of using a jet 88, to accomplish a similar thing.

Fuel that flows through the valve seat 86 (e.g. when the valve element 68 is moved from the valve seat by retraction of the armature 84), flows to the metering valve outlet 70 for delivery into the throttle bore 20. In at least some implementations, fuel that flows through the outlet 70 is directed into the boost venturi 36, when a boost venturi 36 is included in the throttle bore 20. In implementations where the boost venturi 36 is spaced from the outlet 70, an outlet tube 92 (FIG. 3) may extend from a passage or port defining at least part of the outlet 70 and through an opening 94 in the boost venturi wall 44 to communicate with the boost venturi passage 46. The tube 92 may extend into and communicate with the throat 40 of the boost venturi 36 wherein a negative or subatmospheric pressure signal may be of greatest magnitude, and the velocity of air flowing through the boost venturi 36 may be the greatest. Of course, the tube 92 may open into a different area of the boost venturi 36 as desired. Further, the tube 92 may extend through the wall 44 so that an end of the tube projects into the boost venturi passage 46, or the tube may extend through the boost venturi passage so that an end of the tube intersects the opposite wall of the boost venturi and may include holes, slots or other features through which fuel may flow into the boost venturi passage 46, or the end of the tube may be within the opening 94 and recessed or spaced from the passage (i.e. not protruding into the passage).

Fuel may be provided from a fuel source to the metering valve inlet 66 and, when the valve element 68 is not closed on the valve seat 86, fuel may flow through the valve seat and the metering valve outlet 70 and to the throttle bore 20 to be mixed with air flowing therethrough and to be delivered as a fuel and air mixture to the engine. The fuel source may provide fuel at a desired pressure to the metering valve 28. In at least some implementations, the pressure may be ambient pressure or a slightly superatmospheric pressure up to about, for example, 6psi above ambient pressure.

The metering valve 28 may be actuated by a controller 162 (FIG. 1). The controller 162 may be mounted on or otherwise carried by the throttle body assembly 10, or the controller may be located remotely from the throttle body assembly, as desired. In the example shown, the controller 162 is carried within a sub-housing 164 that is mounted to the throttle body 18 and/or cover 118, or otherwise carried by the housing (e.g. the body and/or cover), and which may include a printed circuit board 166 and a suitable microprocessor 168 or other controller for actuation of the metering valve 28, and/or the throttle valve (e.g. when rotated by a motor 62 as shown and described above). Further, information from one or more sensors may be used to control, at least in part, operation of the metering valve 28, and any such sensor(s) may be communicated with the controller 162.

To provide fuel to the metering valve inlet 66, the throttle body assembly 10 may include an inlet chamber 100 (FIG. 3) into which fuel is received from a fuel supply, such as a fuel tank. The throttle body assembly 10 may include a fuel inlet 104 leading to the inlet chamber 100. In a system in which the fuel pressure is generally at atmospheric pressure, the fuel flow may be fed under the force of gravity to the inlet chamber 100. In at least some implementations, as shown in FIGS. 3, 4A, and 4B, a valve assembly 106 may control the flow of fuel into the inlet chamber 100. The valve assembly 106 may include a valve element 108 and may include or be associated with a valve seat 110 so that a portion of the valve element

108 is selectively engageable with the valve seat 110 to inhibit or prevent fluid flow through the valve seat, as will be described in more detail below. The valve element 108 may be coupled to an actuator 112 that moves the valve 108 relative to the valve seat 110, as will be set forth in more detail below. A vent port or passage 102 (FIGS. 4A and 4B) may be
5 communicated with the inlet chamber 100 and with the engine intake manifold or elsewhere as desired so long as the desired pressure within the inlet chamber 100 is achieved in use, which may include atmospheric pressure. The level of fuel within the inlet chamber 100 provides a head or pressure of the fuel that may flow through the metering valve 28 when the metering valve is open.

10 To maintain a desired level of fuel in the inlet chamber 100, the valve 108 is moved relative to the valve seat 110 by the actuator 112 which, in the example shown, includes or is defined by a float that is received in the inlet chamber and is responsive to the level of fuel in the inlet chamber. The float 112 may be buoyant in fuel and provide a lever 117 pivotally coupled to the throttle body 18 or a cover 118 coupled to the body 18 on a pin 119 and the
15 valve 108 may be connected to the float 112 for movement as the float moves in response to changes in the fuel level within the inlet chamber 100. When a desired maximum level of fuel is present in the inlet chamber 100, the float 112 has been moved to a position in the inlet chamber wherein the valve 108 is engaged with and closed against the valve seat 110, which closes the fuel inlet 104 and prevents further fuel flow into the inlet chamber 100. As fuel is
20 discharged from the inlet chamber 100 (e.g., to the throttle bore 20 through the metering valve 28), the float 112 moves in response to the lower fuel level in the inlet chamber and thereby moves the valve 108 away from the valve seat 110 so that the fuel inlet 104 is again open. When the fuel inlet 104 is open, additional fuel flows into the inlet chamber 100 until a maximum level is reached and the fuel inlet 104 is again closed.

The inlet chamber 100 may be defined at least partially by the throttle body 18, such as by a recess formed in the throttle body, and a cavity 121 in the cover 118 carried by the throttle body and defining part of the housing of the throttle body assembly 10. An outlet 120 (FIG. 3) of the inlet chamber 100 leads to the metering valve inlet 66. So that fuel is available at the metering valve 28 at all times when fuel is within the inlet chamber 100, the outlet 120 may be an open passage without any intervening valve, in at least some implementations. The outlet 120 may extend from the bottom or a lower portion of the inlet chamber so that fuel may flow under atmospheric pressure to the metering valve 28.

In use of the throttle body assembly 10, fuel is maintained in the inlet chamber 100 as described above and thus, in the outlet 120 and the metering valve inlet 66. When the metering valve 28 is closed, there is no, or substantially no, fuel flow through the valve seat 86 and so there is no fuel flow to the metering valve outlet 70 or to the throttle bore 20. To provide fuel to the engine, the metering valve 28 is opened and fuel flows into the throttle bore 20, is mixed with air and is delivered to the engine as a fuel and air mixture. The timing and duration of the metering valve opening and closing may be controlled by a suitable microprocessor or other controller. The fuel flow (e.g., injection) timing, or when the metering valve 28 is opened during an engine cycle, can vary the pressure signal at the outlet 70 and hence the differential pressure across the metering valve 28 and the resulting fuel flow rate into the throttle bore 20. Further, both the magnitude of the engine pressure signal and the airflow rate through the throttle valve 52 change significantly between when the engine is operating at idle and when the engine is operating at wide open throttle. In conjunction, the duration that the metering valve 28 is opened for any given fuel flow rate will affect the quantity of fuel that flows into the throttle bore 20.

The inlet chamber 100 may also serve to separate liquid fuel from gaseous fuel vapor and air. Liquid fuel will settle into the bottom of the inlet chamber 100 and the fuel vapor and

air will rise to the top of the inlet chamber where the fuel vapor and air may flow out of the inlet chamber 100 through the vent 102.

Turning now to FIGS. 4A and 4B, flow from the vent 102 may be controlled in part by a vent valve 150. The vent valve 150 may communicate with the vent 102 by way of a vent inlet 152. The vent valve 150 selectively allows flow from the vent inlet 152 to a vent outlet 154. The vent outlet 154 may lead to an evaporative emission canister (not shown) configured to trap or otherwise temporarily contain fuel vapor. Alternatively, the vent outlet 154 may communicate with an intake 26 of the engine 12, allowing vapor therein to be combusted in the engine 12, or with an air filter or air cleaner.

The vent valve 150 may include a valve element 156 having a closed position (FIG. 4A) and an open position (FIG. 4B) dictating in part the flow of fluid through the vent valve 150. The valve element 156 may be pressure-responsive, e.g., by way of a pressure signal inlet 155, as will be described further below. Merely as one example, the valve element 156 may be a diaphragm positioned adjacent a valve seat 157 shown as being defined by a free end of an annular wall 165 in the illustrated example. The diaphragm 156 divides the interior of the valve 150 into a vent chamber 167 defined in part by one side of the diaphragm 156, and a pressure signal chamber 169 defined in part by the opposite side of the diaphragm 156. The vent chamber 167 is communicated with the vent inlet 152 and vent outlet 154. The pressure signal chamber 169 is communicated with a pressure signal source, such as the intake 26 of the engine. Any other pressure-responsive valve element may be used in place of the diaphragm valve element illustrated in FIGS. 4A and 4B, such as, a reed valve or poppet valve.

The diaphragm valve element 156 illustrated in the example of FIGS. 4A and 4B may have an outer portion 158 that is generally fixed, e.g., to interior surface(s) of the vent valve 150, such as by being trapped between two connected bodies 161, 163. The vent valve 156 may also have a moveable inner portion 159 which seals against the valve seat 157 in the closed

position (FIG. 4A). In this manner, the valve element 156 and valve seat 157 may form a closed chamber that inhibits or prevents vapor/fluid at the vent inlet 152 from flowing through the vent valve 150 to the vent outlet 154. Thus, as illustrated in FIG. 4A, vapor (shown by the dashed arrow) reaching the vent inlet 152 generally is contained within the annular wall 165 by the valve element 156 which is closed against the valve seat 157. The diaphragm 156 is shown as directly engaging the valve seat 157 but other constructions and arrangements may be used. For example, the diaphragm may move a separate valve relative to the valve seat, either by engaging the valve directly or by engaging a lever or other component that when moved, moves the valve relative to the valve seat to control fluid flow through the valve seat.

In at least some implementations, a pressure signal applied to a diaphragm opens and closes a valve seat to control fluid flow through the valve seat. As noted above, a reed valve or poppet valve or other pressure responsive valve may be used, if desired.

A negative pressure (e.g. subatmospheric pressure) received in the pressure signal chamber 169 by way of the pressure signal inlet 155 may generally move the inner portion 159 of the diaphragm valve element 156 away from the valve seat 157, thereby permitting vapor or fluid to flow between the valve seat 157 and the valve element 156. Moreover, as shown in FIG. 4B, the opening of the valve element 156 permits vapor (dashed arrow) to flow out of the vent valve 150 through the vent outlet 154.

The vent valve 150 may generally employ a negative pressure source to mechanically actuate the pressure-responsive valve element 156. In at least some examples, an intake of the engine 12 may be used as the negative pressure source. Thus, as negative pressure is generated by operation of the engine 12, e.g., within an intake or intake manifold of the engine 12, the valve element 156 is drawn open. Moreover, to the extent negative pressure of the engine 12 fluctuates or “pulses” during operation, fluctuations in the negative pressure may cycle or cause movement of the valve element 156. Combustion cycles of the engine 12 may create variations

in intake pressure and the draw of negative pressure due to intake valve(s) opening/closing throughout the combustion cycle. In one example, the pulsing of negative pressure at the pressure signal inlet 155 may cycle the valve element 156 between the closed position and the open position. It is possible, however, that pressure at the pressure signal inlet 155 remains negative throughout a combustion cycle, and in such cases the valve element 156 may not fully close during oscillation. Thus, in some cases the valve element 156 may cycle between a fully open position and a partially open position. In at least some implementations, a spring or other biasing member may be used to bias the diaphragm 156 to its closed position, if desired. This may maintain the diaphragm in the closed position until a negative pressure in the pressure signal chamber 169 is greater than a threshold pressure, to further control venting of the vent chamber, if desired.

The vent passage 102, via vent outlet 154, may be coupled to a filter or vapor canister, as noted above. A vapor canister may include an adsorbent material, such as activated charcoal, to reduce or remove hydrocarbons from the vapor, or store hydrocarbons within the canister.

The vent passage 102 could also or instead be coupled to the intake manifold 26 of the engine 12 where the vapor may be added to a combustible fuel and air mixture provided from the throttle bore 20. In this way, vapor and air (i.e. gaseous matter) that flow through the vent valve 150 may be directed to a downstream component as desired. In the implementation shown, the vent outlet 154 extends from the cover 118 downstream of the valve element 156 and to the intake manifold 26 of the engine 12. While the vent outlet 154 and pressure signal inlet 155 are each shown as being defined at least in part in a conduit that is routed outside of the cover 118 and throttle body 18 (see FIG. 2), the vent outlet 154 and pressure signal inlet 155 could instead be defined at least in part by one or more bores or voids formed in the throttle body and/or cover, and or by a combination of internal voids/passages and external conduit(s).

The vent valve 150 may be biased into the closed position. For example, in the absence of negative pressure being generated by the engine 12, e.g., when the engine is off, the valve element 156 may be in the closed position illustrated in FIG. 4A, with the inner portion 159 of the valve element 156 being seated against the annular wall 157, thereby preventing flow of fluid from the vent 102 through the vent valve 150. Accordingly, the vent valve 150 may generally be closed when the engine 12 is off, thereby sealing off the vent passage 102 to avoid the fuel in the inlet chamber 100 from going stale over time (due to evaporation, oxidation or otherwise). In this way, the vent valve 150 may be closed when the device is not being used to reduce the likelihood or rate at which the fuel in the throttle body assembly 10 becomes stale.

The vent valve 150 may be mechanically controlled by way of the negative pressure generated by the engine 12 during operation, and thus a separate control or electronic power is not necessary for operation of the vent valve 150. Alternatively, operation of the vent valve 150 may be subject to an electronic controller, e.g., to adjust magnitude of negative pressure, timing thereof, or other aspects of the vent valve 150. In such examples, the same controller 162 (FIG. 1) that actuates the fuel metering valve 28 may be used to control operation of the vent valve 150, or a separate controller may be employed.

As shown in FIG. 5, a fuel system 200 may include a fuel tank 202, a throttle body assembly 10 and an engine 12 having an intake manifold 26. The fuel tank 202 may include an interior 204 in which a supply of liquid fuel 206 is maintained for delivery to the engine 12 via the throttle body assembly 10 as set forth above. The liquid fuel may flow from the fuel tank 202 (under the force of gravity or via a pump) through a first conduit 208 to the inlet chamber 100 of the throttle body assembly 10. From the inlet chamber 100, the liquid fuel may flow to the throttle bore 20, and from the throttle bore to the intake manifold 26 of the engine 12 in a fuel and air mixture (the flow from the throttle bore to the intake manifold is

diagrammatically shown as occurring through a conduit 210, but a conduit is not necessary when the throttle body 18 is mounted to the intake manifold 26). The inlet chamber 100 may be vented to the intake manifold 26 via a second conduit 212, and gaseous flow through the second conduit may be controlled by a vent valve 150, e.g., having a pressure-responsive valve element, as set forth above.

Further, an upper region 214 of the fuel tank 202 includes air and fuel vapor above the level of liquid fuel 206. This upper or vapor region 214 of the fuel tank 202 may be communicated with the inlet chamber 100 via a third conduit 216 so that the fuel tank air/vapor (e.g. gaseous matter) may be vented in the same manner that the inlet chamber 100 is vented, with the gaseous flow also controlled by the inlet chamber vent valve 150. Hence, a single vent valve 150 may be used to control the venting of gasses from both the inlet chamber 100 of the throttle body assembly 10 and the fuel tank 202. In this way, an internal pressure within the tank 202 may be controlled, and this may be done without a separate vent valve carried by the fuel tank. Because a vent outlet 218 and conduit 216 can be closed off by the inlet chamber vent valve 150, and because the vent valve 150 may be biased to the closed position when the engine 12 is not operating, fuel will generally not leak from the fuel tank 202 via the vent opening or conduit, for example, if the fuel tank is inverted while the engine 12 is not operating. Thus, a costly and more complex roll-over valve (i.e., a valve that closes the fuel tank vent outlet 218 if the fuel tank is inverted) may not be needed in this fuel system 200 as is commonly used when a separate vent valve is connected to the fuel tank.

While the vent valve 150 may be mechanically actuated as described above, it is also possible to electronically or otherwise control the vent valve to effect proper venting of both the inlet chamber 100 and the fuel tank 202, including the manner(s) set forth herein above. For example, further venting schemes may be used to facilitate adding fuel to the fuel tank whereupon a refueling event is detected and the vent valve 150 is opened, or cycled between

opened and closed positions, to permit vapor and air to escape from the fuel tank and facilitate adding fuel into the fuel tank. Of course, other venting schemes and control methods may be employed, as desired.

Turning now to FIG. 6, an example process flow diagram is shown for a process 600 of venting a charge forming device, e.g., a throttle body. Process 600 may begin at block 605, where a housing is provided having a throttle bore with an inlet through which air is received, an inlet chamber in which a supply of fuel is received, and a vent communicating with the inlet chamber. For example, throttle body 18 may be provided with an inlet 20 receiving air and an inlet chamber 100 receiving a supply of fuel, as discussed above. Additionally, a vent 102 may be provided that communicated with the inlet chamber 100. Process 600 may then proceed to block 610.

At block 610, a throttle valve may be provided in the housing, with the throttle valve having a valve head movable relative to the throttle bore to control fluid flow through the throttle bore. For example, as discussed above a throttle valve 52 may have a moveable valve head 54 controlling flow of fluid through the throttle bore 20.

Proceeding to block 615, a vent valve may be communicated with the vent passage via a vent inlet. For example, as noted above an example vent valve 150 may be in communication with the vent 102 by way of a vent inlet 152. The vent valve 150 may have a valve element 156, a vent outlet 154, and a pressure signal inlet 155, with the pressure signal inlet 155 in communication with a pressure source. The valve element 156 may have a closed position, in which fluid flow through the vent valve is inhibited or prevented, and an open position in which fluid may flow through the vent valve. As discussed above, in some example approaches the valve element may be a pressure-responsive valve element such as a diaphragm. A diaphragm may inhibit or prevent fluid flow by engagement or seating of a moveable portion 159 of the

diaphragm with an annular wall 157 of the vent valve 150. Process 600 may then proceed to block 620.

At block 620, the valve element may be biased toward the closed position. In one example approach discussed above, a moveable portion 159 of the valve element 156 may be
5 biased into contact with annular wall 157, thereby inhibiting or preventing flow through the vent valve 150 to the vent outlet 154. Accordingly, in the absence of a negative pressure signal being communicated to the pressure signal inlet 155, or if a negative pressure is insufficient to overcome the bias of the valve element 156, the vent valve 150 generally may remain closed.

Proceeding to block 625, a pressure signal may be communicated to the valve element
10 via the pressure signal inlet, thereby moving the valve element to the open position to permit fluid flow from the vent inlet to the vent outlet. Merely by way of example, engine 12 may develop negative pressure within intake manifold 26, which may be communicated with the pressure signal inlet 155 of the vent valve 150. The negative pressure may draw the pressure-responsive valve element 156 away from annular wall 157, thereby allowing vapor or fluid to
15 flow from the vent inlet 152 to the vent outlet 154. As also discussed above, the vent outlet 154 may be in communication with an evaporative emission canister or trap, or the vent outlet 154 may be in communication with an intake of the engine 12. In either case, fuel vapor present in the inlet chamber 100 and/or fuel tank 202 may generally be captured, thereby reducing or preventing loss of fuel vapor emissions to the external environment. Additionally, in some
20 example illustrations, the pressure signal to the pressure signal inlet 155 may be pulsed, e.g., as may occur during a combustion cycle of the engine 12, thereby cycling the valve element 156 between the open position and the closed position.

The forms of the invention herein disclosed constitute presently preferred embodiments and many other forms and embodiments are possible. It is not intended herein to mention all
25 the possible equivalent forms or ramifications of the invention. It is understood that the terms

used herein are merely descriptive, rather than limiting, and that various changes may be made without departing from the spirit or scope of the invention.

As used in this specification and claims, the terms “for example,” “for instance,” “e.g.,” “such as,” and “like,” and the verbs “comprising,” “having,” “including,” and their other verb forms, when used in conjunction with a listing of one or more components or other items, are each to be construed as open-ended, meaning that that the listing is not to be considered as excluding other, additional components or items. Other terms are to be construed using their broadest reasonable meaning unless they are used in a context that requires a different interpretation.

CLAIMS

1. A charge forming device for a combustion engine, comprising:

a housing having a throttle bore with an inlet through which air is received, an inlet chamber in which a supply of fuel is received, and a vent communicating with the inlet chamber;

a throttle valve carried by the housing with a valve head movable relative to the throttle bore to control fluid flow through the throttle bore; and

a vent valve communicating with the vent, the vent valve having a vent inlet in communication with the vent, a valve element having a closed position in which fluid flow through the vent inlet is inhibited or prevented and an open position in which fluid may flow through the vent inlet, the vent valve having a pressure signal inlet in communication with a pressure source, and a vent outlet selectively communicated with the vent inlet when the valve element is in the open position, wherein a pressure signal is provided to the valve element through the pressure signal inlet to cause the valve element to move between the open position and closed position to control fluid flow from the vent inlet to and through the vent outlet.

2. The device of claim 1, wherein the vent outlet communicates with an evaporative emissions canister configured to store fuel vapor.

3. The device of claim 1, wherein the vent outlet communicates with an air intake of the engine.

4. The device of claim 1, wherein the pressure source is an intake manifold of the engine.

5. The device of claim 1, wherein the valve element is a diaphragm.

6. The device of claim 5, wherein the vent valve comprises an annular wall defining in part an inner chamber of the vent valve.

7. The device of claim 6, wherein an inner portion of the diaphragm contacts the annular wall in the closed position, the inner portion of the diaphragm spaced away from the annular wall in the open position.

8. The device of claim 1, further comprising an electrically actuated fuel metering valve carried by the housing and having an inlet communicated with the inlet chamber to receive fuel from the inlet chamber and an outlet communicated with the throttle bore and through which fuel is supplied into the throttle bore.

9. The device of claim 1, further comprising an inlet valve carried by the housing and having a valve that controls the flow of fuel into the inlet chamber.

10. The device of claim 9, wherein the inlet valve is coupled to a float received within the inlet chamber to actuate the inlet valve as a function of the level of fuel within the inlet chamber.

11. The device of claim 1, further comprising a second vent passage providing gaseous matter from a second source to the inlet chamber, wherein flow of gaseous matter from the inlet chamber and from the second source is controlled by the vent valve.

12. The device of claim 11, wherein the second source is a fuel tank.

13. A method of venting a charge forming device for a combustion engine, comprising:
providing a housing having a throttle bore with an inlet through which air is received, an inlet chamber in which a supply of fuel is received, and a vent communicating with the inlet

chamber;

installing a throttle valve in the housing, the throttle valve having a valve head movable relative to the throttle bore to control fluid flow through the throttle bore;

communicating a vent valve with the vent passage via a vent inlet, the vent valve having
5 a valve element, a pressure signal inlet in communication with a pressure source, and a vent outlet, the valve element having a closed position in which fluid flow through the vent valve is inhibited or prevented and an open position in which fluid may flow through the vent valve;

biasing the valve element toward the closed position; and

communicating a pressure signal to the valve element via the pressure signal inlet,
10 thereby moving the valve element to the open position to permit fluid flow from the vent inlet to the vent outlet.

14. The method of claim 13, further comprising communicating the vent outlet with an evaporative emissions canister configured to store fuel vapor.

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15. The method of claim 13, further comprising communicating the vent outlet with an air intake of the engine.

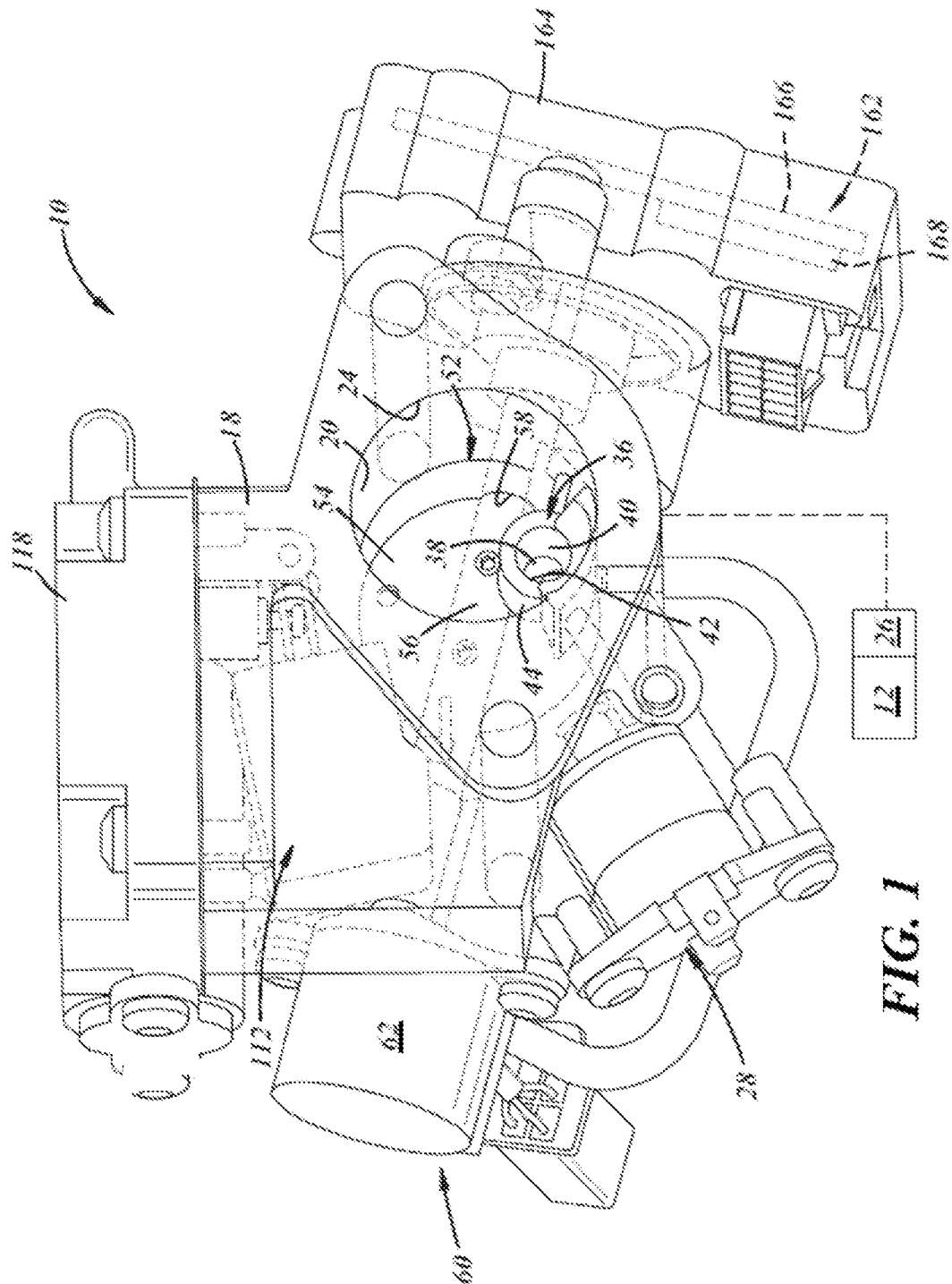
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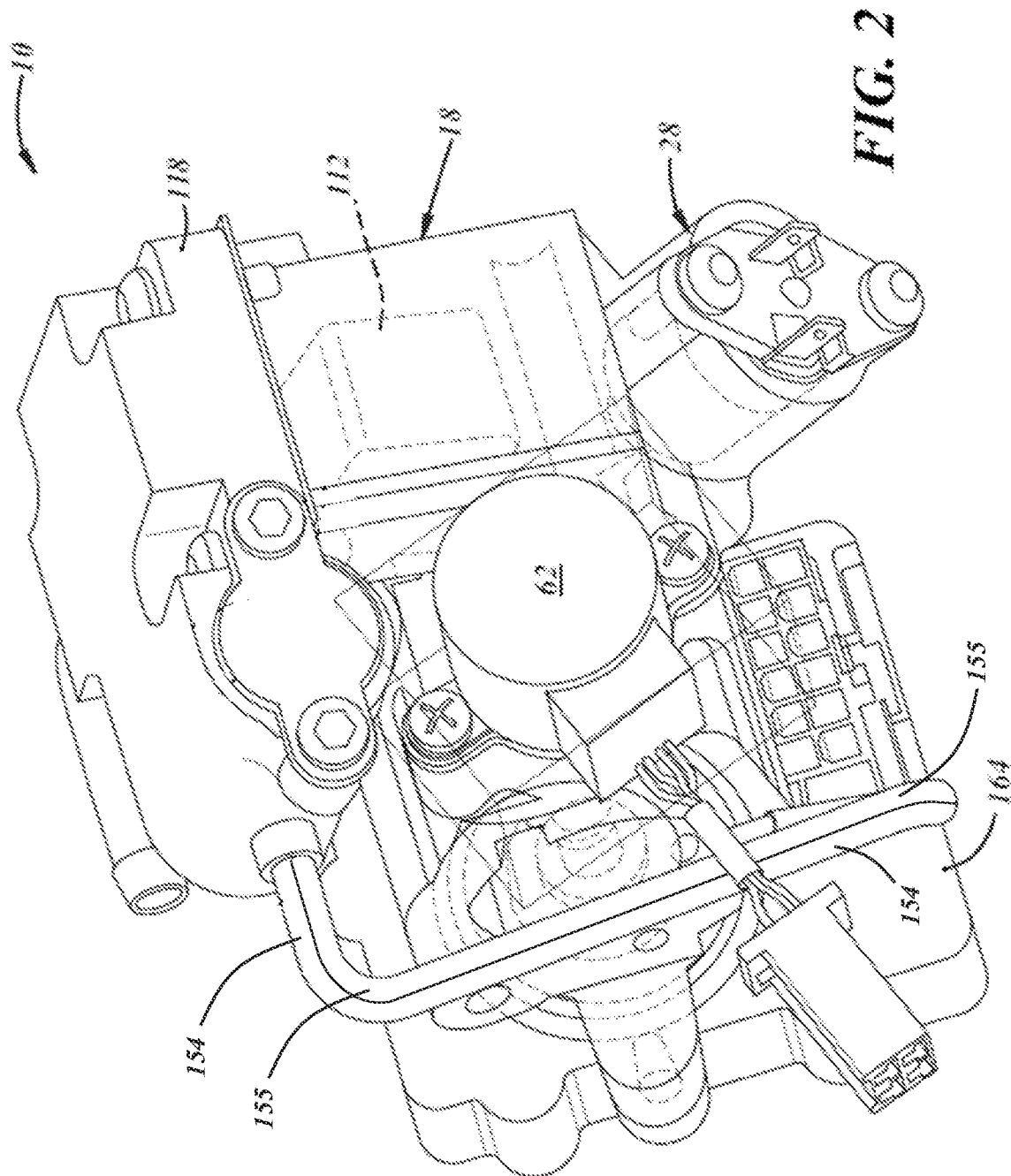
16. The method of claim 13, wherein the pressure source is an intake manifold of the engine.

17. The method of claim 13, wherein the valve element is a diaphragm.

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18. The method of claim 13, further comprising pulsing the pressure signal, thereby cycling the valve element between the open position and the closed position.





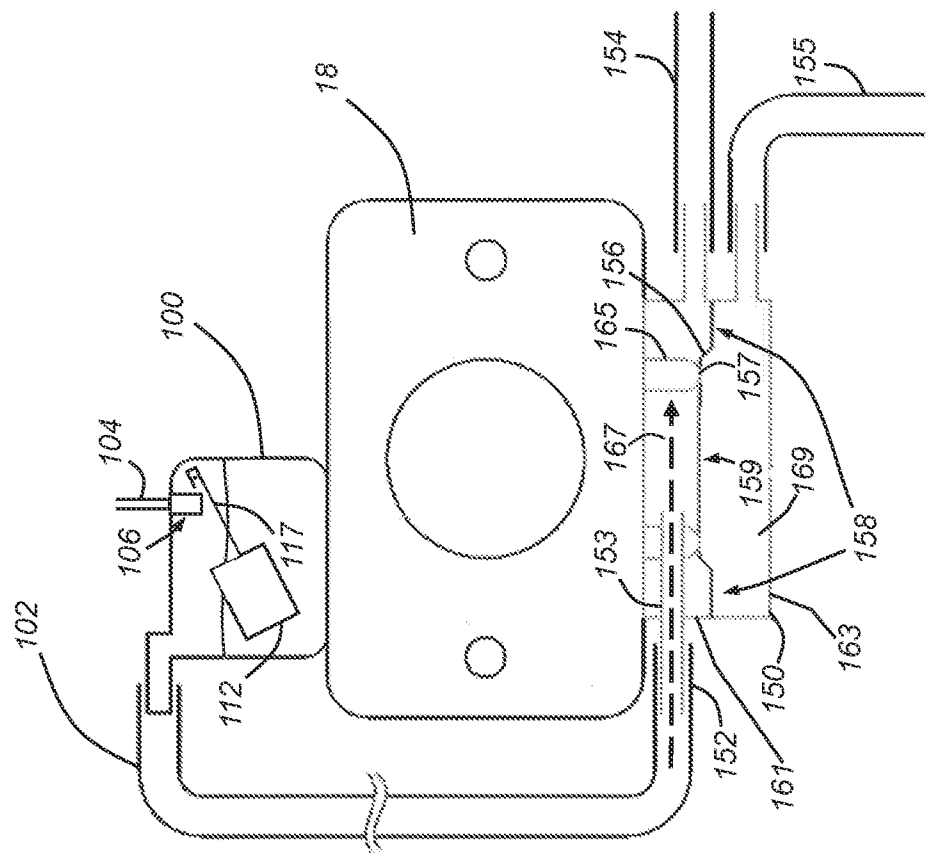
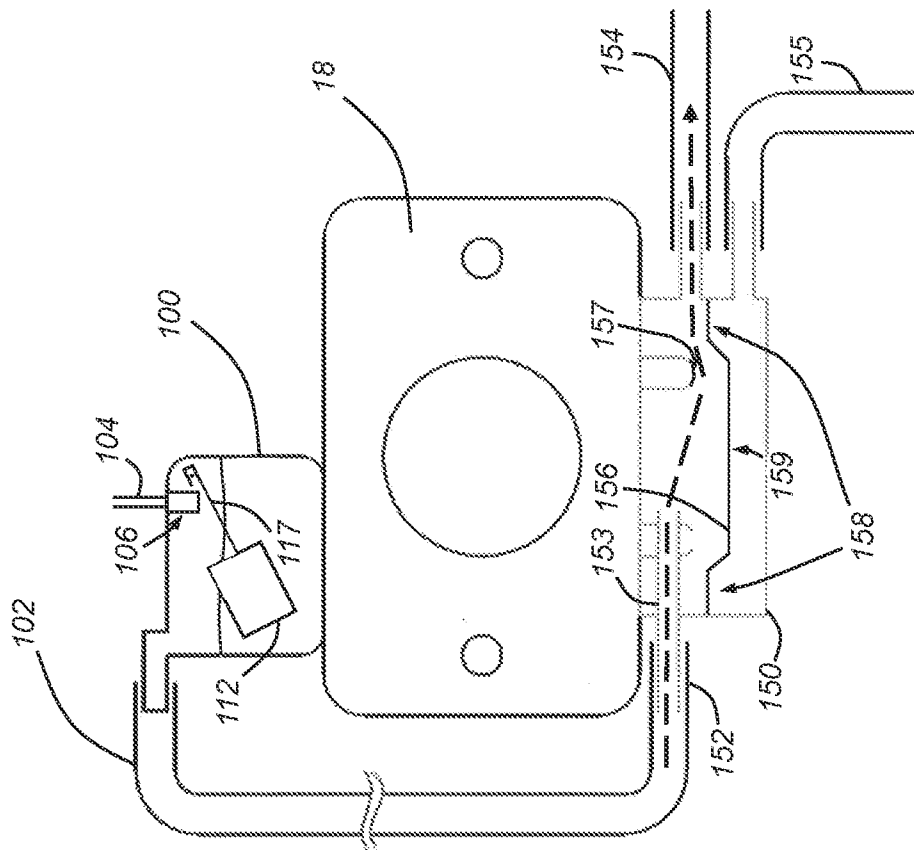


FIG. 4A

FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2021/047730

A. CLASSIFICATION OF SUBJECT MATTER F02M 7/14(2006.01)i; F02M 7/22(2006.01)i; F02M 25/08(2006.01)i; F02M 9/12(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F02M 7/14(2006.01); F02D 9/10(2006.01); F02M 17/04(2006.01); F02M 25/00(2006.01); F02M 33/08(2006.01); F02M 5/08(2006.01); F02M 9/08(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: throttle body, inlet chamber, fuel vapor, vent, valve, diaphragm, pressure signal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2019-055447 A1 (WALBRO L.L.C.) 21 March 2019 (2019-03-21) page 4, line 19 - page 10, line 15, page 12, line 1 - page 14, line 25, page 16, line 24 – page 17, line 19, claim 1, and figures 1-6	1-4,8-16,18
Y		5-7,17
Y	US 4283356 A (ARAI et al.) 11 August 1981 (1981-08-11) column 2, line 24 - column 3, line 22, claim 1, and drawing	5-7,17
A	US 2013-0104849 A1 (BRIGGS & STRATTON CORPORATION) 02 May 2013 (2013-05-02) paragraphs [0017]-[0022] and figure 1	1-18
A	US 5545357 A (RADEL et al.) 13 August 1996 (1996-08-13) column 2, line 43 - column 3, line 57 and drawing	1-18
A	US 4208997 A (YOSHIDA et al.) 24 June 1980 (1980-06-24) column 2, line 24 - column 3, line 35 and figure 1	1-18
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 30 November 2021		Date of mailing of the international search report 01 December 2021
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer BAHNG, SEUNG HOON Telephone No. +82-42-481-5560

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2021/047730

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				JP	57-045897	B	30 September 1982
				US	4275696	A	30 June 1981