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(54) **FUEL PUMP**

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(57) **ABSTRACT**

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A filter device is connected to a fuel pump for supplying filtered fuel to an internal combustion engine. The filter device has a bag-shaped filter element forming therein a fuel passage, wherein fuel passes through the filter element to enter into the fuel passage. The filter element further forms a vapor pooling chamber above the fuel passage, so that vapors separated from the filtered fuel in the fuel passage are moved toward the vapor pooling chamber. A valve device is provided at a portion of the filter device, which is close to the vapor pooling chamber, so that vapors are discharged from the vapor pooling chamber to an outside of the filter device.

(30) **Foreign Application Priority Data**

Dec. 14, 2009 (JP) 2009-283058

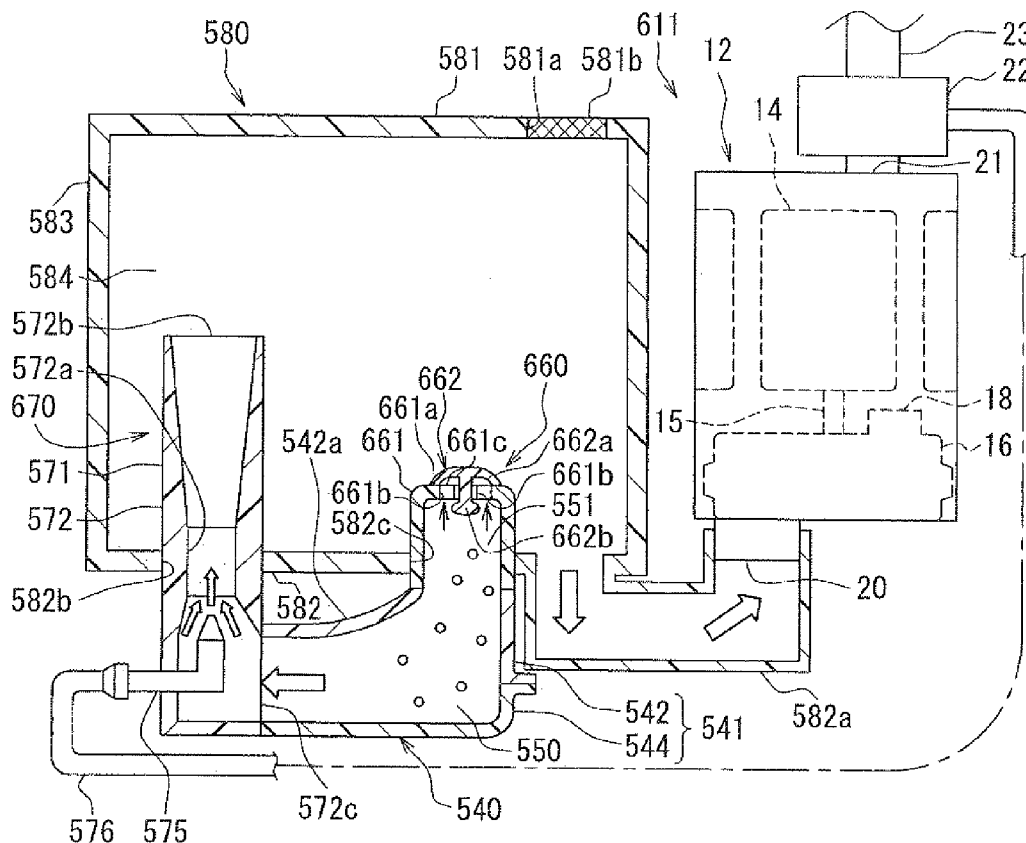


FIG. 1

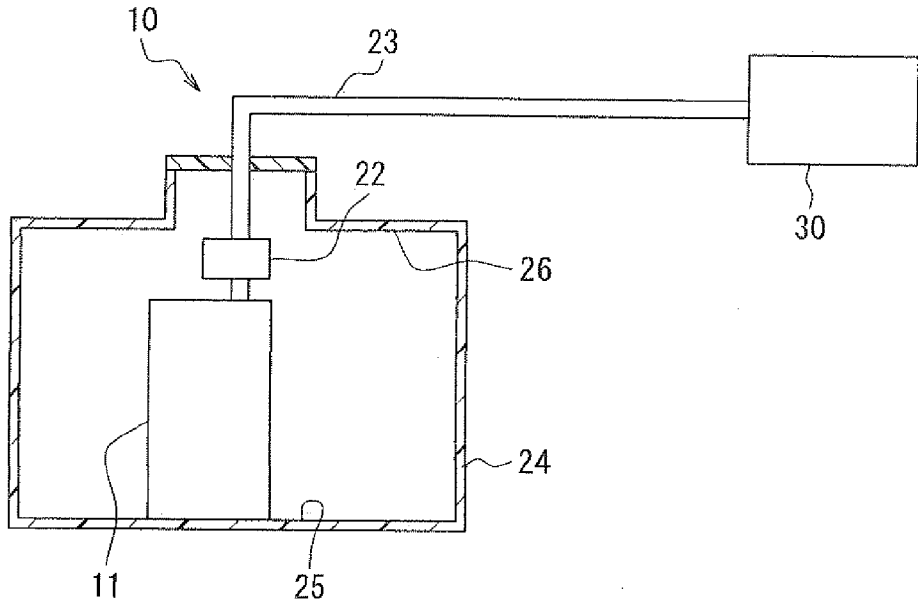


FIG. 2

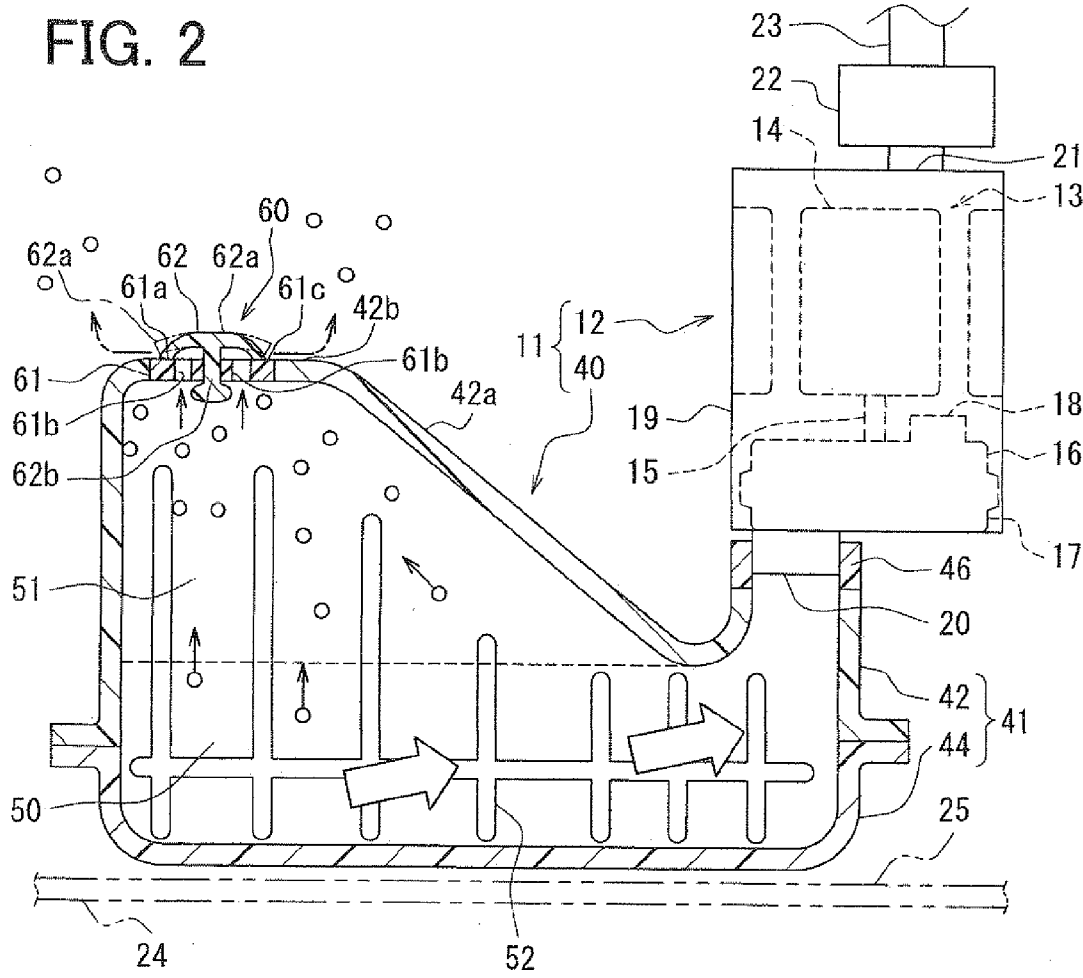


FIG. 3

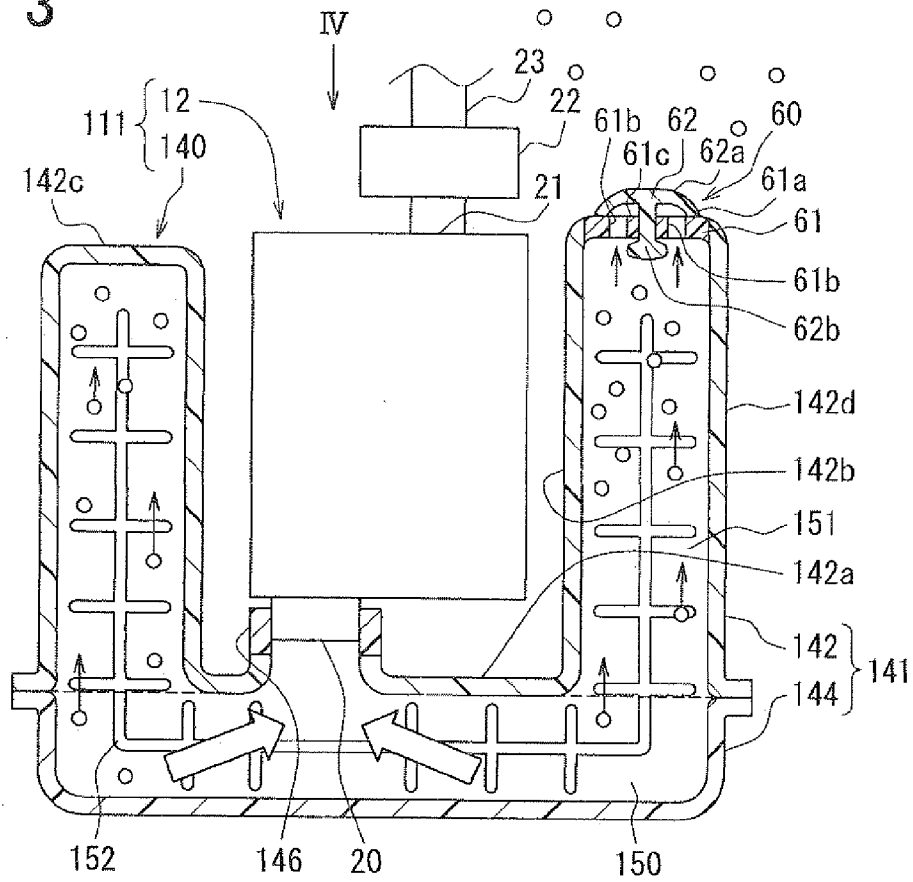


FIG. 4

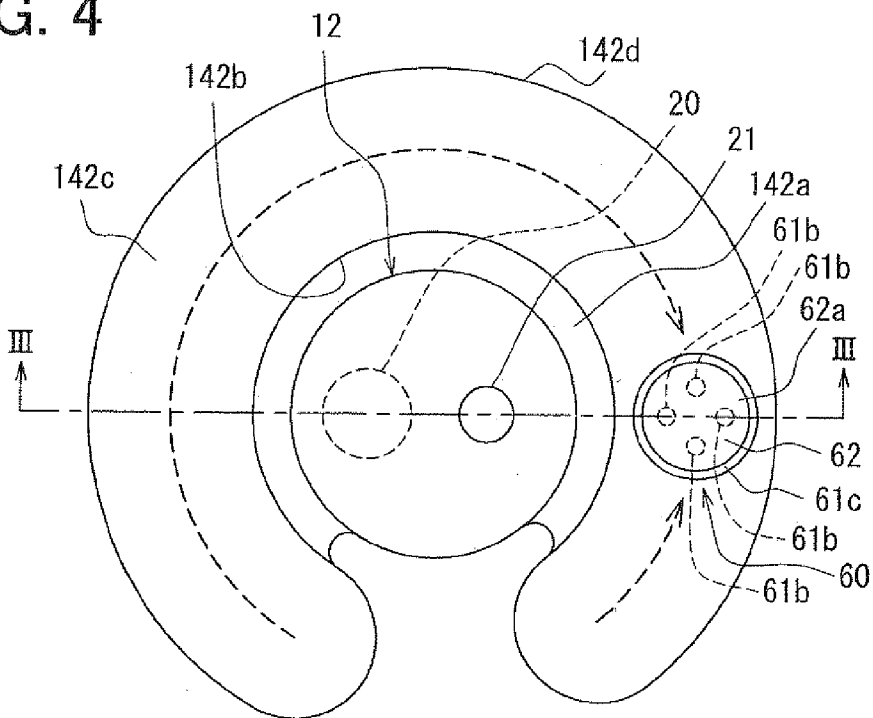


FIG. 5

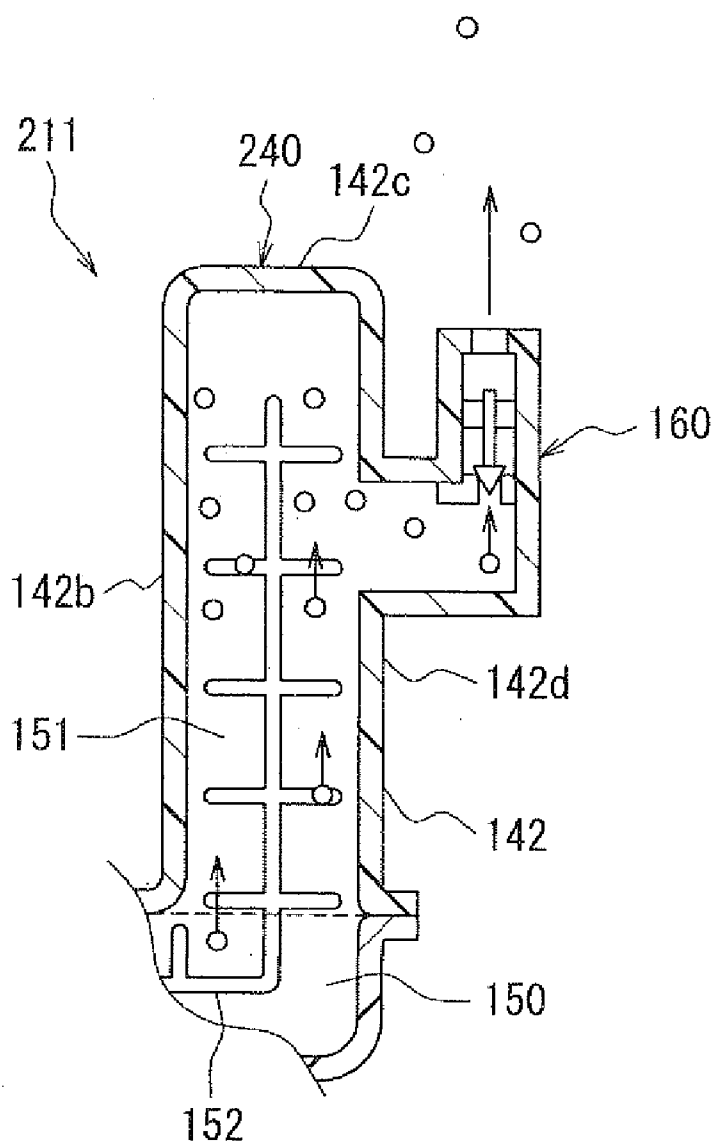


FIG. 6

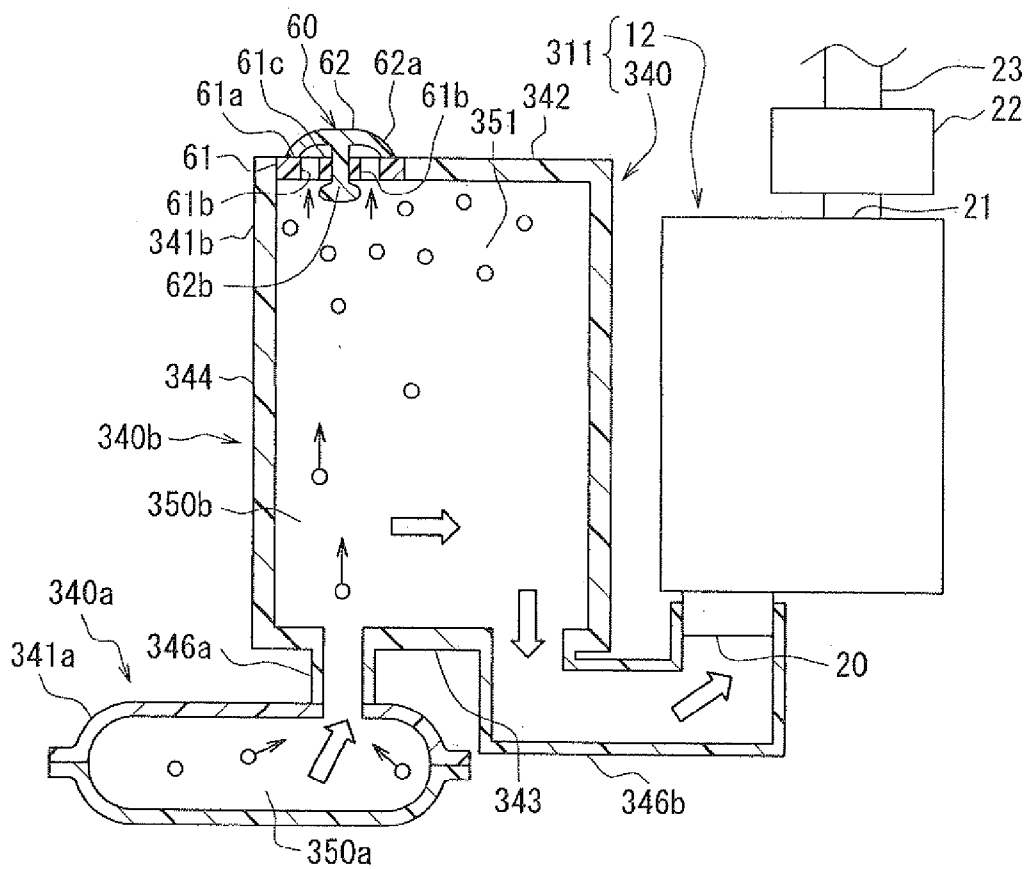


FIG. 7

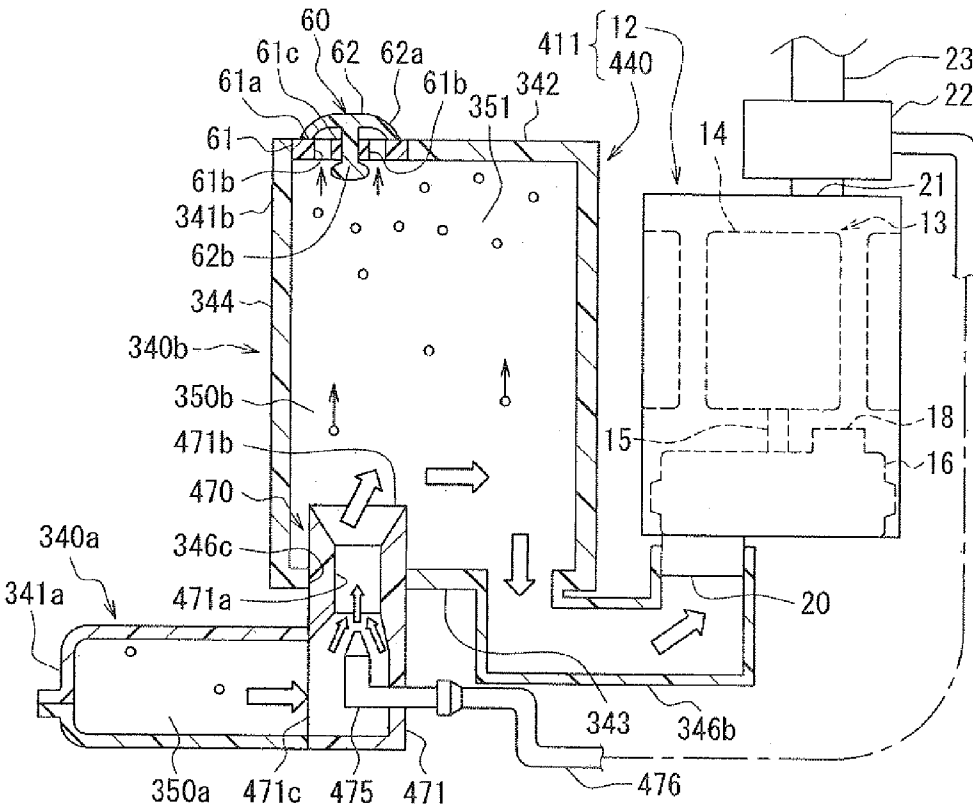


FIG. 8

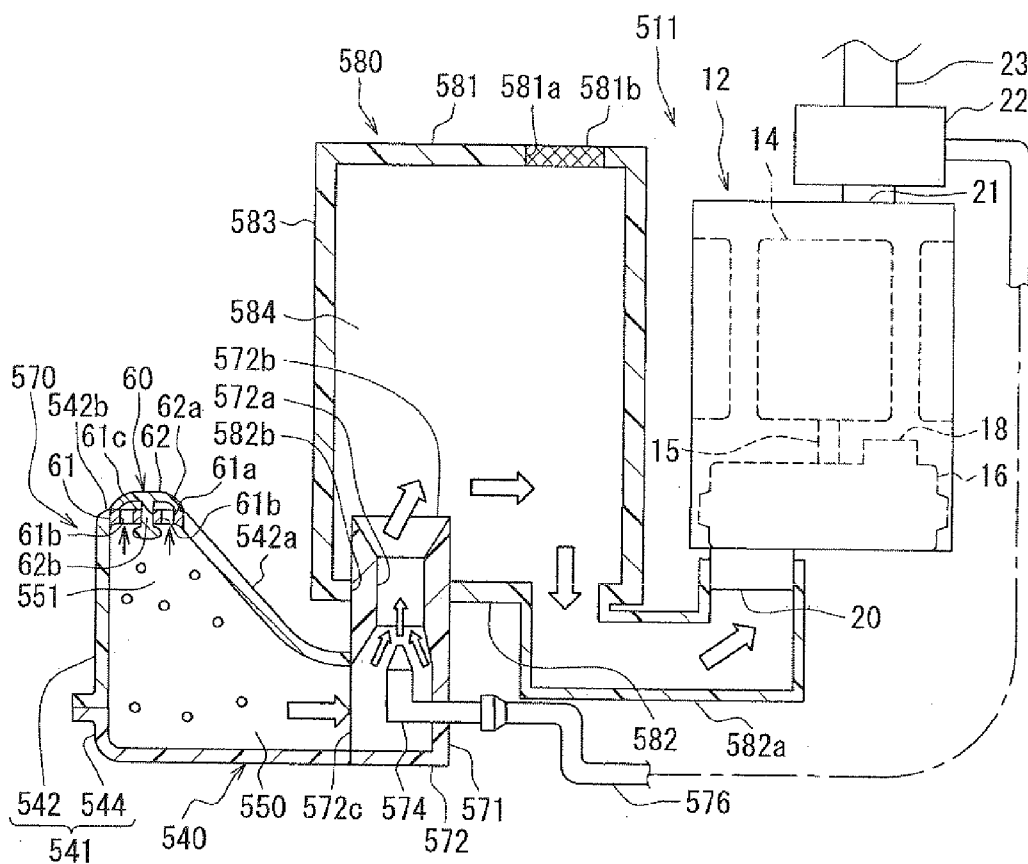


FIG. 9

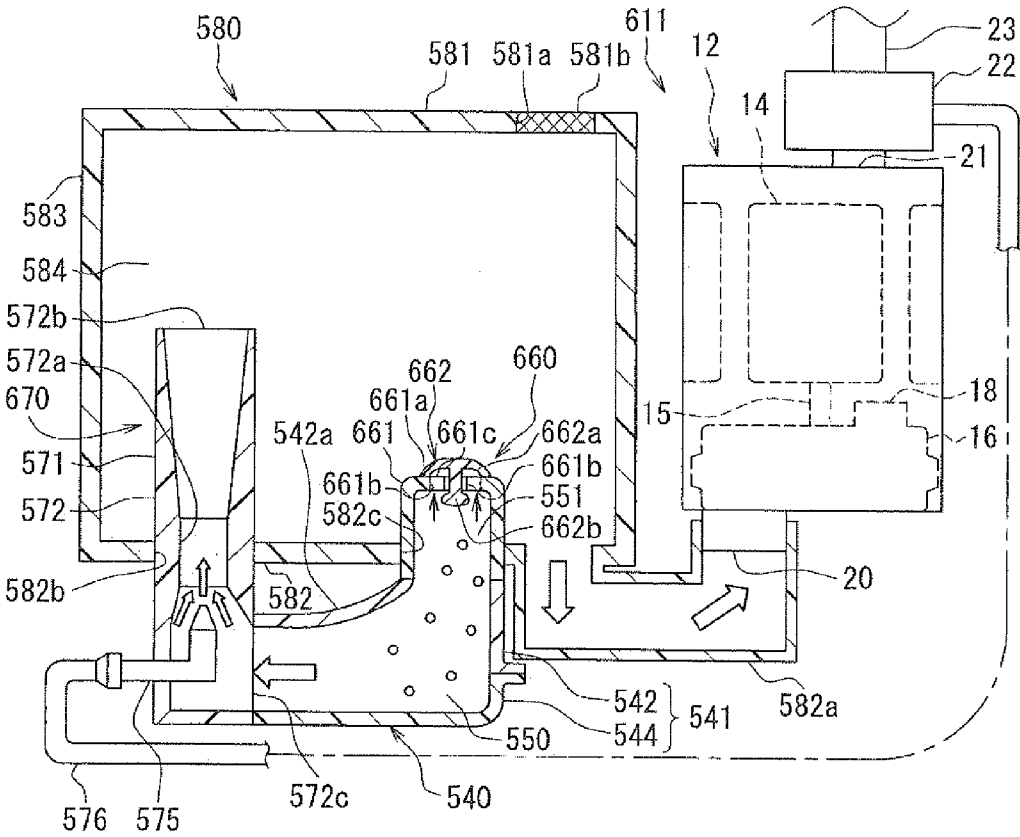


FIG. 10

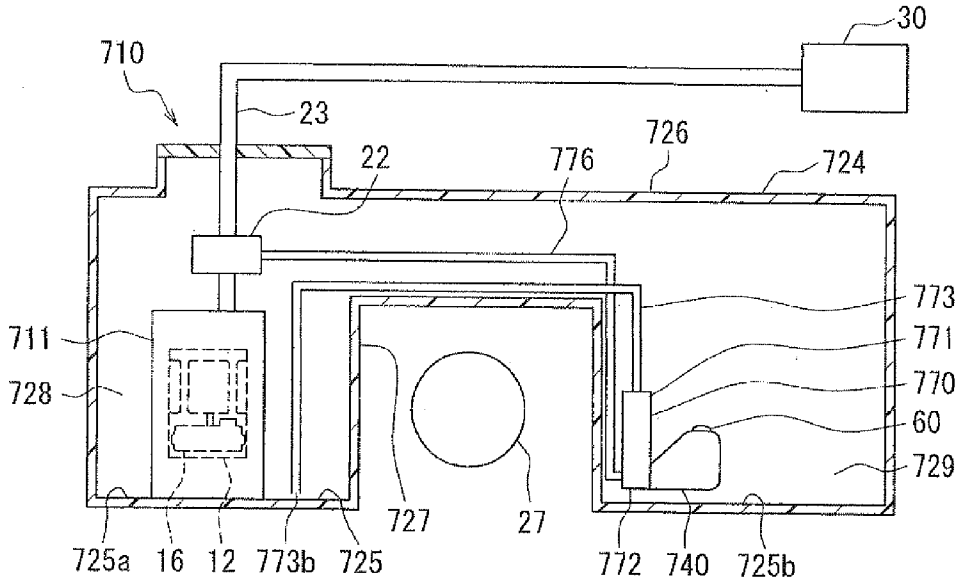


FIG. 11

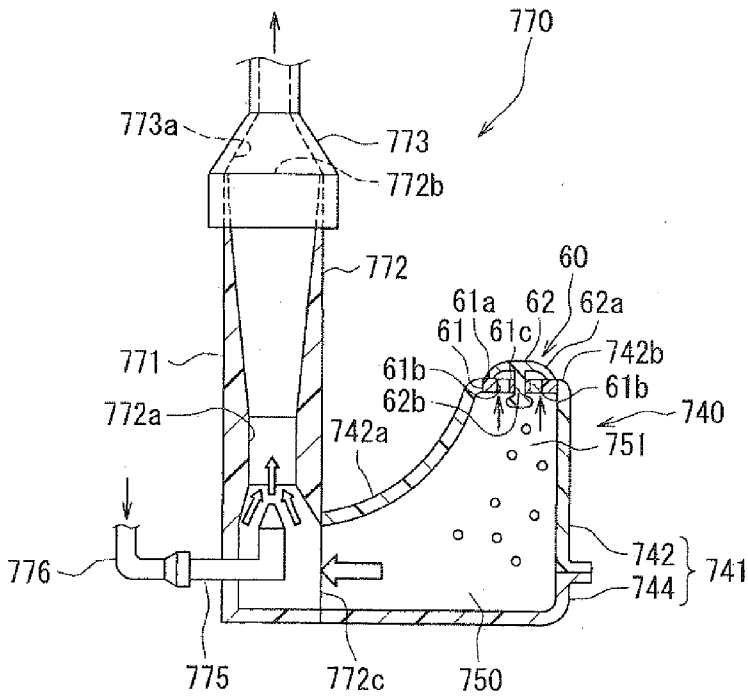


FIG. 12

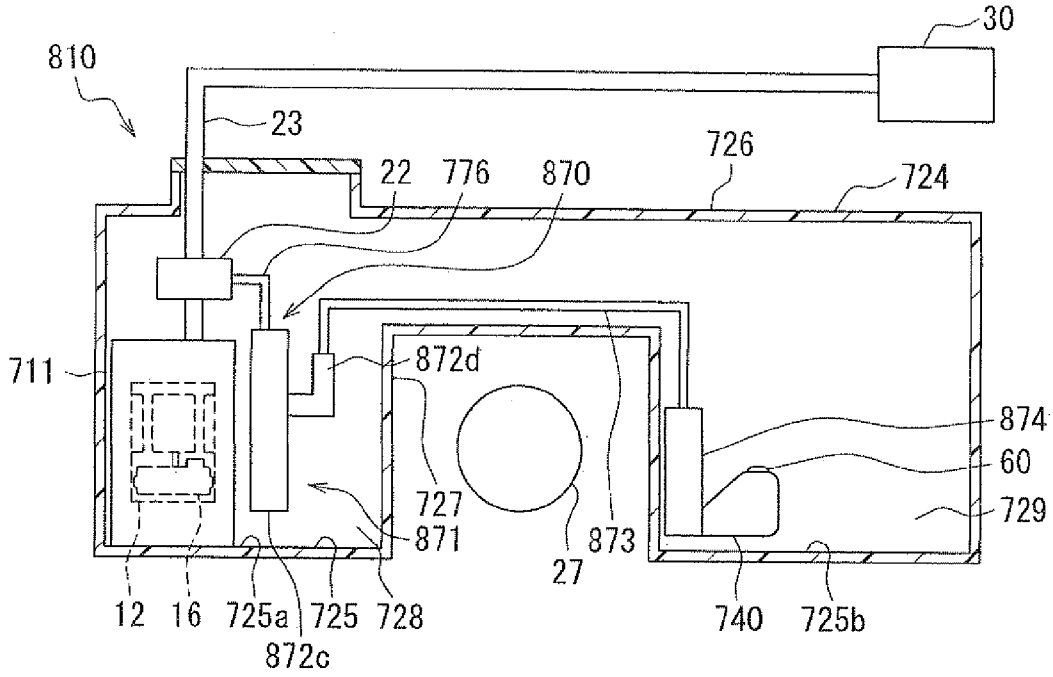


FIG. 13

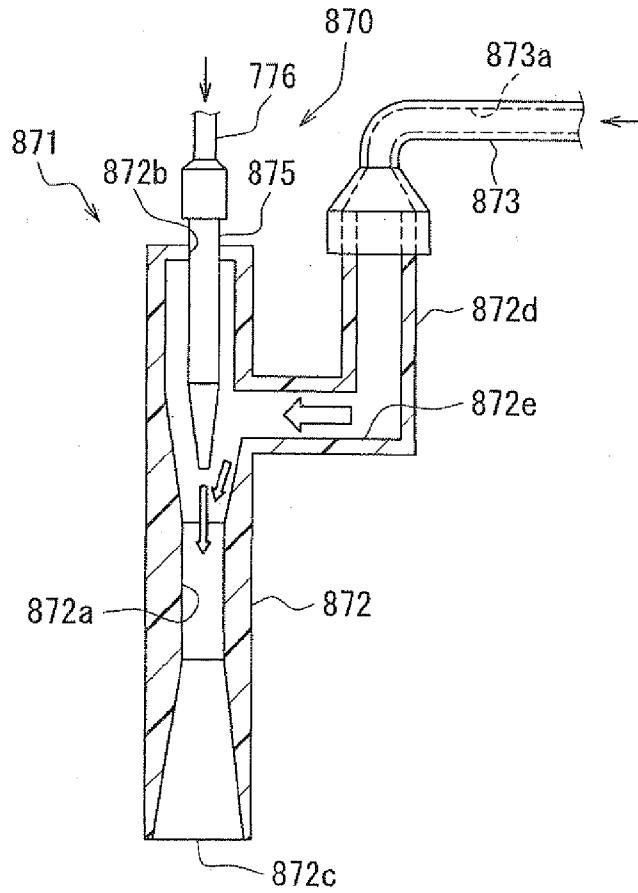
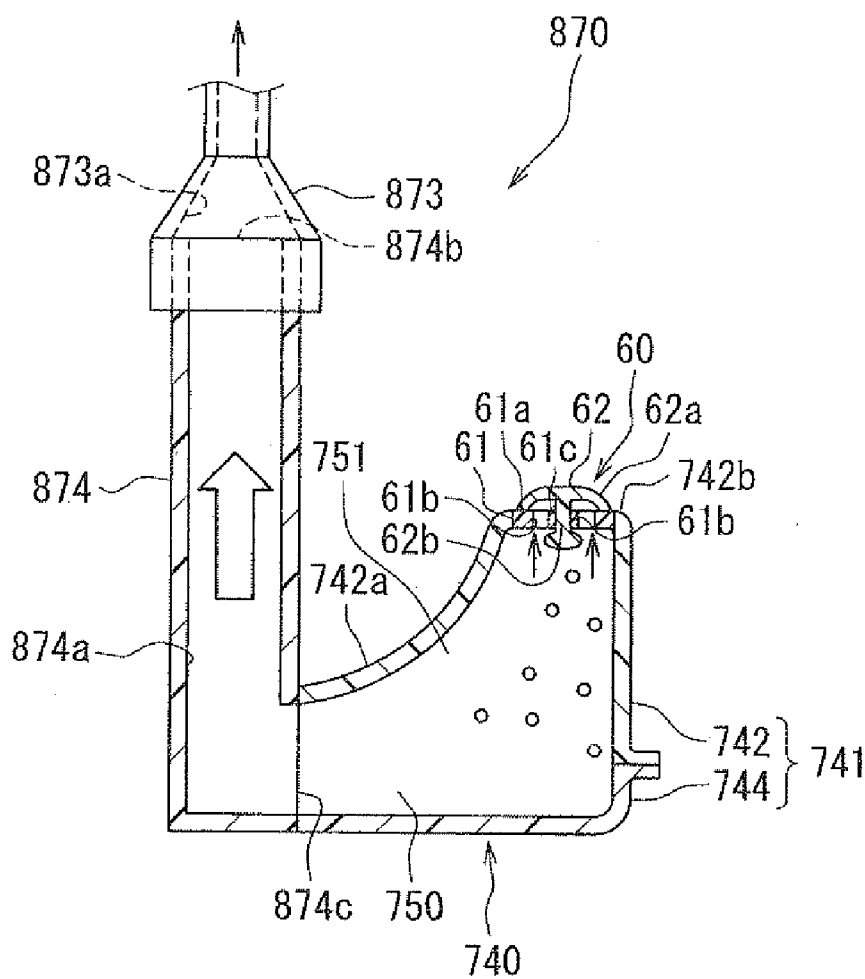


FIG. 14



FUEL PUMP

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is based on Japanese Patent Application No. 2009-283058 filed on Dec. 14, 2009, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a fuel pump for supplying fuel to an internal combustion engine (an engine).

BACKGROUND OF THE INVENTION

[0003] A fuel pump is known in the art, according to which the fuel pump has a pump device for generating a fuel drawing force for drawing fuel through a suction port and pumping out the fuel from a discharge port, and a filter device for filtering the fuel to be sucked into the pump device.

[0004] Generally, when vapors are included in the fuel to be sucked into the pump device through the suction port, the pump device can not discharge the fuel, which at least corresponds to a volume of the vapors. Therefore, a discharge fuel amount of the pump device is decreased when compared with a case in which no vapors are mixed into the fuel. Various structures have been proposed in the art in order to prevent the vapors from mixing into the fuel to be sucked into the pump device (for example, as disclosed in Japanese Patent Publications No. 2006-029317 and H07-180632).

[0005] According to the Japanese Patent Publication No. 2006-029317, an expansion chamber is provided at an upper side of a fuel suction filter. The fuel suction filter is formed in a bag shape for filtering fuel to be supplied into a pump device. A part of fuel discharged from a pressure regulating valve, which regulates fuel pressure of the fuel pumped out from the pump device, is supplied into the expansion chamber. According to the above structure, vapors contained in the fuel flowing into the expansion chamber are separated from the fuel, and such fuel is then supplied into the fuel suction filter, to thereby reduce a condition of negative pressure in the fuel suction filter, in which the negative pressure is generated during an operation of the pump device. As a result of reducing the negative pressure, it is possible to suppress generation of vapors in the fuel suction filter.

[0006] According to the Japanese Patent Publication No. H07-180632, a mesh filter body is provided for filtering fuel to be sucked into a pump device. A return fuel chamber is formed at an upper side of the mesh filter body, so that a part of the mesh filter at the upper side forms a bottom wall of the return fuel chamber. Namely, the upper side mesh filter forms a partitioning wall between the mesh filter body and the return fuel chamber. According to such a structure, vapors included in the return fuel may be separated from the fuel in the return fuel chamber and such separated fuel is supplied into the mesh filter body through the partitioning wall. The fuel supplied into the mesh filter body is then sucked into the pump device.

[0007] According to the above prior art (JP 2006-029317), since the negative pressure is reduced in the fuel suction filter, it is possible to suppress the generation of vapors to some extent. For example, when fuel alcohol having a relatively low boiling point is included in gasoline, or when fuel temperature is rather high, vapors may be generated. In addition, in a case that the fuel suction filter is composed of a filter

element made of non-woven material, fuel liquid film may be formed on a surface of the fuel suction filter when the fuel is permeated into the filter. Then, the fuel may pass through the filter element, but the vapors can not pass through the filter element. As a result, the vapors generated within the fuel suction filter may not be discharged to an outside of the filter and may stay in the filter.

[0008] Then, the vapors generated in the fuel suction filter flow together with fuel, which will be sucked into the pump device. Therefore, the pump device may decrease its discharge amount.

[0009] According to the above other prior art (H07-180632), although it is possible to separate the vapors from the return fuel, the vapors generated in the mesh filter body due to the operation of the pump device may not pass through the partitioning wall formed between the mesh filter body and the return fuel chamber and may stay in the mesh filter body.

[0010] When thus generated vapor stays in the filter body, the vapor may flow together with the fuel to be sucked into the pump device and may finally be sucked into the pump device. As a result, the pump device may decrease its discharge amount.

SUMMARY OF THE INVENTION

[0011] The present invention is made in view of the above problems. It is an object of the present invention to provide a fuel pump, according to which it is possible to suppress that vapors generated in a filter device may flow toward a suction port of a pump device, so that decrease of discharge amount from the pump device may be suppressed.

[0012] According to a feature of the present invention, for example, as defined in the appended claim 1, a fuel pump comprises a pump device having a suction port and a discharge port. The pump device generates fuel suction force at the suction port and discharges pressurized fuel from the discharge port. The fuel pump further has a filter device connected to the suction port for filtering the fuel to be sucked into the pump device. The filter device includes an outer shell having a filter element of a film shape for filtering the fuel to be sucked into the pump device. The outer shell forms therein a fuel passage for guiding the fuel filtered by the filter element to the suction port of the pump device. The outer shell further forms a vapor pooling chamber above the fuel passage and communicated with the fuel passage so that vapors included in the fuel flowing through the fuel passage are moved from the fuel passage toward the vapor pooling chamber. A valve device is provided at a portion of the outer shell for communicating the vapor pooling chamber to an outside of the outer shell when an amount of the vapors pooled in the vapor pooling chamber reaches at a predetermined value.

[0013] According to the above feature, since the filter device is connected to the suction port of the pump device, the fuel pressure in the filter device is decreased by fuel suction force generated by the operation of the pump device, so that the fuel pressure in the filter device becomes lower than the fuel pressure outside of the filter device. Since at least a portion of the outer shell of the filter device is formed by the filter element of the thin film for filtering the fuel, the fuel outside of the filter device passes through the filter element to enter into the fuel passage formed in the filter device. In the fuel passage, fuel flow flowing toward the pump device is generated when the pump device is in operation. The fuel

having entered into the fuel passage flows along such fuel flow and is sucked into the pump device through the suction port thereof.

[0014] However, vapors may be generated when the fuel passes through the filter element and is filtered thereby, because the fuel pressure in the filter device is lower than the fuel pressure outside of the filter device. According to the present invention, the vapor pooling chamber is formed in the outer shell above the fuel passage, so that the vapors are able to upwardly move by buoyancy thereof and the vapors are moved to the vapor pooling chamber. As above, the vapors are separated from the filtered fuel in the filter device.

[0015] Since the vapors can be separated from the filtered fuel and pooled in the vapor pooling chamber of the filter device, as above, it is possible to suppress flow-in of the vapors which would otherwise be sucked into the suction port of the pump device. In addition, it is possible to suppress a decrease of pump discharge amount.

[0016] When an amount of the vapors exceeds a predetermined value (a capacity of the vapor pooling chamber), there may be a danger that such vapors may flow into the filtered fuel in the fuel passage, because the vapor pooling chamber is communicated with the fuel passage.

[0017] According to the above feature of the invention, however, the valve device is provided at the outer shell of the filter device, at such a portion at which the vapor pooling chamber is formed, so that the vapor pooling chamber is communicated to the outside of the filter device when the vapors are pooled in the vapor pooling chamber to thereby discharge the vapors from the vapor pooling chamber to the outside of the filter device. Therefore, it is possible, according to the above structure, to suppress a generation of a problem that the vapors may overflow from the vapor pooling chamber and the separated vapors may flow into the fuel passage. It is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount.

[0018] According to another feature of the present invention, for example, as defined in the appended claim 2, a liquid film of the fuel is formed at a surface of the filter element when the fuel entered into the filter element, and the liquid film of the fuel allows the fuel to pass through the filter element but prevents the vapors from passing pass through the filter element.

[0019] When the filter element having the above behaviors is used, the vapors generated in the filter device may not be discharged to the outside thereof through the filter element. When the amount of the vapors exceeds a capacity of the vapor pooling chamber, there may be a danger that the vapors may flow into the fuel passage. However, the filter device of the present invention has the valve device, through which the vapors may be discharged to the outside of the filter device. It is, therefore, possible to discharge the vapors to the outside of the filter device before the amount of the vapors may exceeds the capacity of the vapor pooling chamber. As a result, even in the case that the filter element having the above behaviors may be used, it is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount, which may be caused by the flow-in of the vapors into the pump device.

[0020] According to a further feature of the present invention, for example, as defined in the appended claim 3, the outer shell has a slope wall portion at an upper side thereof, and the slope wall portion is upwardly inclined such that a height of the slope wall portion becomes larger as the slope

wall portion is closer to the valve device. The vapors tend to upwardly move due to the buoyancy. Since the slope wall portion is formed at the upper side of the outer shell and upwardly inclined toward the valve device, the vapors are moved upwardly to the valve device along the slope wall portion. According to such a feature, it is possible to surely guide the vapors to the valve device and to smoothly discharge the vapors to the outside of the filter device.

[0021] According to a still further feature of the present invention, for example, as defined in the appended claim 4, the slope wall portion is formed by the filter element. Since the slope wall portion is formed by the filter element, the fuel having passed through the filter element enters into the fuel passage below the vapor pooling chamber. The vapors pooled in the vapor pooling chamber receives pressure from the fuel having entered into the fuel passage, so that the vapors are effectively discharged to the outside of the filter device.

[0022] According to a still further feature of the present invention, for example, as defined in the appended claim 5, the slope wall portion is upwardly inclined such that the height of the slope wall portion becomes larger as the slope wall portion is further away from the suction port. When the vapors are moved by the buoyancy along the slope wall portion, the vapors are moved away from the suction port of the pump device. Therefore, it is possible to suppress the flow-in of the vapors into the suction port.

[0023] According to a still further feature of the present invention, for example, as defined in the appended claim 6, the valve device is provided at a highest position of the outer shell, so that the slope wall portion is upwardly inclined toward the valve device. Since the valve device is provided at the highest position of the outer shell and the slope wall portion is upwardly inclined toward the valve device, the vapors are upwardly moved toward the valve device. As a result, it is possible to surely guide the vapors to the valve device and to smoothly discharge the vapors to the outside of the filter device.

[0024] According to a still further feature of the present invention, for example, as defined in the appended claim 7, the valve device comprises a valve seat member having a seat portion formed at an outer surface of the filter device and a communication hole formed at an inner area of the seat portion for communicating the vapor pooling chamber to the outside of the filter device. The valve device further comprises a valve body member disposed at the outer surface of the filter device, wherein the valve body member is pushed by the vapors in the vapor pooling chamber and thereby separated from the seat portion, so that the valve body member allows the vapors to flow from the vapor pooling chamber to the outside of the filter device, while the valve body member is seated on the seat portion when the amount of the vapors in the vapor pooling chamber is decreased so that the valve body member prevents the fuel from flowing from the outside of the filter device into the inside of the filter device.

[0025] According to the above feature, the valve body member is arranged at the outer surface of the filter device (at the valve seat member having the seat portion) and the communication hole is formed at the inner area of the seat portion. Therefore, the valve body member is pushed out by the vapors flowing from the inside to the outside of the filter device and thereby separated from the seat portion. As a result, the vapors are discharged from the vapor pooling chamber to the outside of the filter device. On the other hand, when the amount of the vapors in the vapor pooling chamber is decreased, the valve

body member is seated on the seat portion. As a result, the fuel is prevented from flowing from the outside to the inside of the filter device through the communication hole.

[0026] As above, since the vapors pooled in the vapor pooling chamber are discharged to the outside of the filter device, it is possible to suppress that the vapors flow into the fuel passage. In addition, since it is possible to prevent the fuel from entering into the inside of the filter device through the valve device, it is possible to surely guide the filtered fuel (filtered by the filter element) to the suction port of the pump device.

[0027] According to a still further feature of the present invention, for example, as defined in the appended claim 8, the fuel passage is composed of a first fuel passage and a second fuel passage. The second fuel passage is formed between the first fuel passage and the suction port of the pump device so that the first fuel passage is communicated to the suction port. The outer shell is composed of the filter element and a tank wall member of a tank portion, wherein the filter element forms therein the first fuel passage, while the tank portion forms therein the second fuel passage and the vapor pooling chamber above the second fuel passage. The filter element is provided at a lower end of the tank portion, so that the first fuel passage is communicated to the second fuel passage, and the valve device is provided at a portion of the tank portion, at which the vapor pooling chamber is formed.

[0028] According to the above feature, the filter element forming therein the first fuel passage is provided at the lower end of the tank portion, so that the first fuel passage is communicated to the second fuel passage formed in the tank portion. When the pump device is operated, the fuel suction force is generated. The fuel outside of the filter device passes through the filter element to enter into the first fuel passage. Then, the fuel flows into the second fuel passage and finally into the suction port of the pump device. The vapors, which are generated when the fuel passes through the filter element, flow from the first fuel passage to the second fuel passage.

[0029] The vapors having entered into the second fuel passage are upwardly moved by the buoyancy to the vapor pooling chamber, which is formed above the second fuel passage. Since the vapor pooling chamber is formed by the tank portion, which does not allow the fuel (as well as the vapors) to pass through the tank wall member of the tank portion, the vapors can not be discharged to the outside of the filter device through the tank portion. The vapors are discharged to the outside of the filter device only through the valve device, which is provided at the tank portion.

[0030] As above, even in the case that the outer shell of the filter device is composed of the filter element and the tank wall member, it is possible to separate the vapors from the filtered fuel in the filter device, and to suppress the flow-in of the vapors into the suction port of the pump device. It is possible, for a long term, to exert the effect for suppressing the flow-in of the vapors into the suction port.

[0031] According to a still further feature of the present invention, for example, as defined in the appended claim 9 and in the same manner to the claim 7, the valve device comprises a valve seat member provided at the tank portion, the valve seat member having a seat portion formed at an outer surface of the filter device and a communication hole formed at an inner area of the seat portion for communicating the vapor pooling chamber to the outside of the filter device. The valve device further comprises a valve body member disposed at the outer surface of the filter device, wherein the

valve body member is pushed by the vapors in the vapor pooling chamber and thereby separated from the seat portion so that the valve body member allows the vapors to flow from the vapor pooling chamber to the outside of the filter device, while the valve body member is seated on the seat portion when the amount of the vapors in the vapor pooling chamber is decreased so that the valve body member prevents the fuel from flowing from the outside of the filter device into the inside of the filter device.

[0032] According to the above feature, the valve body member is arranged at the outer surface of the filter device (at the valve seat member having the seat portion) and the communication hole is formed at the inner area of the seat portion. Therefore, the valve body member is pushed out by the vapors flowing from the inside to the outside of the filter device and thereby separated from the seat portion. As a result, the vapors are discharged from the vapor pooling chamber to the outside of the filter device. On the other hand, when the amount of the vapors in the vapor pooling chamber is decreased, the valve body member is seated on the seat portion. As a result, the fuel is prevented from flowing from the outside to the inside of the filter device through the communication hole.

[0033] Therefore, even when the fuel level around the filter device is decreased to be lower than the fuel level in the tank portion, it is possible to hold the fuel in the tank portion. This function (holding the fuel in the tank portion) is continued even in a non-operation period of the pump device.

[0034] According to a still further feature of the present invention, for example, as defined in the appended claim 10, the fuel pump further comprises an auxiliary jet pump provided between the first fuel passage and the second fuel passage. The auxiliary jet pump has a throat portion forming a fuel jet passage, one end of which is opened to the first fuel passage and the other end of which is opened to the second fuel passage. The auxiliary jet pump further has a fuel jet portion provided in the fuel jet passage for emitting fuel toward the other end of the fuel jet passage opened to the second fuel passage.

[0035] According to the above feature of the invention, the fuel jet portion is provided in the fuel jet passage of the throat portion in such a way that the fuel is emitted toward the other end of the fuel jet passage opened to the second fuel passage. Therefore, when the fuel is emitted from the fuel jet portion, the fuel pressure around the fuel jet portion is decreased to thereby generate the fuel suction force at the auxiliary jet pump for sucking the fuel from the first fuel passage.

[0036] When the fuel flows, due to the fuel suction force, from the first fuel passage into the fuel jet passage of the throat portion, the fuel pressure in the first fuel passage is decreased. Then, the fuel outside of the filter device passes through the filter element to enter into the first fuel passage. The fuel having entered into the fuel jet passage of the throat portion flows into the second fuel passage along with the fuel emitted from the fuel jet portion.

[0037] As above, the fuel suction force is generated in the auxiliary jet pump when the fuel is emitted from the fuel jet portion. The fuel in the first fuel passage is forcibly transferred by the fuel suction force to the second fuel passage. It is, therefore, possible to fully fill the tank portion with fuel.

[0038] Accordingly, even when the fuel level around the filter device is decreased, it is possible to keep the fuel level in the tank portion above the fuel level around the filter device. Since the auxiliary jet pump forcibly discharges the fuel into the second fuel passage, it is possible to forcibly and

smoothly discharge the vapors pooled in the vapor pooling chamber to the outside of the filter device through the valve device.

[0039] According to a still further feature of the present invention, for example, as defined in the appended claim 11, a filter frame is provided in the filter device for supporting an inner surface of the outer shell.

[0040] Generally, the filter element made of the film sheet does not have enough mechanical strength to be used as an outer shell of the filter device. It is, therefore, difficult for the filter element of the film sheet to keep the shape of the outer shell of the filter device.

[0041] According to the above feature, the filter frame is provided in the filter device for supporting the inner surface of the outer shell. Therefore, even when any external force is applied to the filter element, the shape of the filter element can be maintained. Namely, the shape of the fuel passage as well as the vapor pooling chamber, each of which is formed inside of the filter element, can be maintained.

[0042] According to a still further feature of the present invention, for example, as defined in the appended claim 12, the pump device is composed of an electric pump for generating the fuel suction force in order to draw the fuel from the suction port, the electric pump pressurizes the fuel and discharges such pressurized fuel from the discharge port.

[0043] In the electric pump, in which the fuel is sucked through the suction port by the fuel suction force generated by the operation of the electric pump and the fuel is pressurized and discharged from the discharge port, the fuel discharge amount from the electric pump is decreased at least by such an amount of the vapors, which have been sucked into the electric pump together with the fuel.

[0044] According to the present invention, the flow-in of the vapors into the electric pump is suppressed and thereby the decrease of the pump discharge amount is suppressed.

[0045] According to a still further feature of the present invention, for example, as defined in the appended claim 13, the fuel pump has a jet pump. The jet pump is composed of a throat portion forming therein a fuel jet passage, which has an inlet open end and an outlet open end. The jet pump further has a fuel jet portion provided in the fuel jet passage for emitting fuel toward the outlet open end, so that fuel suction force is generated at the inlet open end. In the jet pump, the fuel sucked into the fuel jet passage from the inlet open end is discharged from the outlet open end together with the fuel emitted from the fuel jet portion.

[0046] When the fuel is emitted from the fuel jet portion, the fuel pressure around the fuel jet portion is decreased, so that the fuel suction force is generated to draw the fuel through the inlet open end. The fuel drawn from the inlet open end is discharged from the outlet open end together with the fuel emitted from the fuel jet portion. When vapors are included in the fuel drawn into the jet pump through the inlet open end, it may become difficult to sufficiently decrease the fuel pressure around the fuel jet portion, to thereby decrease the fuel suction force. Then, the pump discharge amount from the jet pump may be decreased.

[0047] According to the present invention, however, the flow-in of the vapors into the jet pump is effectively suppressed, and thereby the decrease of the pump discharge amount of the jet pump can be effectively suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] The above and other objects, features and advantages of the present invention will become more apparent

from the following detailed description made with reference to the accompanying drawings. In the drawings:

[0049] FIG. 1 is a schematic view showing a fuel supply system incorporating a fuel supply device according to a first embodiment of the present invention;

[0050] FIG. 2 is a schematic cross sectional view showing the fuel supply device shown in FIG. 1;

[0051] FIG. 3 is a schematic cross sectional view (taken along a line in FIG. 4) showing a fuel supply device according to a second embodiment of the present invention;

[0052] FIG. 4 is a top plan view of the fuel supply device when viewed in a direction of an arrow IV in FIG. 3;

[0053] FIG. 5 is a schematic enlarged cross sectional view showing a filter device of a fuel supply device according to a modification of the second embodiment;

[0054] FIG. 6 is a schematic cross sectional view showing a fuel supply device according to a third embodiment of the present invention;

[0055] FIG. 7 is a schematic cross sectional view showing a fuel supply device according to a modification of the third embodiment;

[0056] FIG. 8 is a schematic cross sectional view showing a fuel supply device having a suction pump according to a fourth embodiment of the present invention;

[0057] FIG. 9 is a schematic cross sectional view showing a fuel supply device having a suction pump according to a modification of the fourth embodiment;

[0058] FIG. 10 is a schematic view showing a fuel supply system incorporating a fuel transfer pump according to a fifth embodiment of the present invention;

[0059] FIG. 11 is a schematic cross sectional view showing the fuel transfer pump shown in FIG. 10;

[0060] FIG. 12 is a schematic view showing a fuel supply system incorporating a fuel transfer pump according to a modification of the fifth embodiment;

[0061] FIG. 13 is a schematic enlarged cross sectional view showing a jet pump of the fuel transfer pump shown in FIG. 12; and

[0062] FIG. 14 is a schematic enlarged cross sectional view showing a filter device of the fuel transfer pump shown in FIG. 12.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0063] Embodiments of the present invention will be explained with reference to the drawings. The same reference numerals are used throughout the embodiments for designating the same or similar parts or components.

First Embodiment

[0064] A first embodiment of the present invention will be explained with reference to the drawings. FIG. 1 is a schematic view showing a fuel supply system 10 incorporating a fuel supply device 11 according to the first embodiment of the present invention.

[0065] In the fuel supply system 10, fuel in a fuel tank 24 is supplied to an engine 30 outside of the fuel tank. The fuel supply system 10 according to the present embodiment is a so-called return fuel supply system, in which surplus fuel which will not be consumed by the engine 30 is treated in an inside of the fuel tank 24 so that the surplus fuel may not be return from the engine 30. The fuel supply system 10 is

composed of the fuel supply device 11, a pressure regulating device 22 and a fuel supply pipe 23, and so on.

[0066] The fuel supply device 11 and the pressure regulating device 22 will be explained with reference to FIG. 2. FIG. 2 shows a cross sectional view of the fuel supply device 11. The fuel supply device 11, the pressure regulating device 22 and a part of the fuel supply pipe 23 are disposed in the inside of the fuel tank 24. The fuel supply device 11 has a suction port 20, which is directed (opened) to a bottom wall 25 of the fuel tank 24, and a discharge port 21, which is directed (opened) to an upper wall 26 of the fuel tank 24. The discharge port 21 is provided at an opposite side to the bottom wall 25. The fuel supply device 11 draws the fuel from the fuel tank 24, pressurizes the fuel, and pumps out the pressurized fuel to the pressure regulating device 22 through the discharge port 21. The fuel supply pipe 23 is connected to the discharge port 21.

[0067] The pressure regulating device 22 is provided in the fuel supply pipe 23 and regulates fuel pressure discharged from the fuel supply device 11, so that the fuel is finally supplied to the engine 30. According to the present embodiment, the pressure regulating device 22 discharges surplus fuel, which is a part of the fuel to be supplied to the engine 30 and split out of the fuel when regulating the fuel pressure, into the fuel tank 24.

[0068] The fuel supply device 11 is composed of an electric pump device 12, a filter device 40 and so on. The electric pump device 12 is composed of an electric motor 13, a pump portion 16, and so on, wherein those components are accommodated in a cylindrical housing 19.

[0069] The electric motor 13 is a DC motor driven by direct current supplied from a battery (not shown). The electric motor 13 drives the pump portion 16. The electric motor 13 is composed of a rotor 14 to be rotated upon receiving electric power and a shaft 15 to be rotated together with the rotor 14. According to the present embodiment, the electric motor 13 is disposed in the fuel tank 24 in such a way that the rotor 14 and the shaft 15 thereof are vertically arranged in the fuel tank 24.

[0070] The pump portion 16 comprises a Wesco type pump having an impeller. The pump portion 16 is provided at an axial end of the electric motor 13 on a side to the bottom wall 25 of the fuel tank 24. The pump portion 16 has a pump housing 17, which rotatably accommodates the impeller of a disc shape. Multiple blade grooves are formed at outer peripheries of both axial side surfaces of the impeller, wherein the multiple blade grooves are arranged in a circumferential direction. In addition to rotatably accommodating the impeller, the pump housing 17 has pressure increasing passages of an arc shape at each of axial inner surfaces, each of which faces to the respective axial side surfaces of the impeller in an axial direction. Each one end of the pressure increasing passages is communicated to the suction port 20, while each other end thereof is communicated to a pump outlet port 18.

[0071] As shown in FIG. 2, the suction port 20 is formed at a lower end of the pump housing 17, which is on the side to the bottom wall 25 of the fuel tank 24, so that the suction port 20 is communicated to an inlet portion of the pressure increasing passage. The pump outlet port 18 is formed at an upper side of the pump housing 17, which is an opposite side of the suction port 20, so that the pump outlet port 18 is communicated to an outlet portion of the pressure increasing passage.

[0072] According to the above structure, when the impeller is rotated by the electric motor 13, fuel suction force is generated at the pump portion 16. As a result, the fuel around the

suction port 20 flows into the inlet portion of the pressure increasing passage through the suction port 20. The fuel sucked into the pressure increasing passage is pressurized as the fuel is forced to flow toward the outlet portion of the pressure increasing passage, so that the fuel is discharged from the pump outlet port 18. The fuel discharged from the pump outlet port 18 flows into a space accommodating the electric motor 13 and then the fuel is pumped out through the discharge port 21, which is formed at an upper end of the housing 19 (an opposite side to the pump portion 16). The pump portion 16 is explained as being composed of an impeller type pump. However, any other type of the pump, such as, for example, a trochoid type pump having a trochoid gear, may be used to the pump portion 16.

[0073] The filter device 40 is connected to the suction port 20 so as to trap extraneous material included in the fuel to be sucked into the electric pump 12 through the suction port 20. The filter device 40 is composed of a filter element 41, a connecting member 46, a filter frame 52, a valve device 60 and so on. As shown in FIG. 2, the filter element 41 is made of non-woven film sheets (made of resinous fiber) and formed in a flat bag extending along the bottom wall 25 of the fuel tank 24. The filter element 41 traps the extraneous material contained in the fuel when the fuel passes through the filter element 41.

[0074] When the fuel enters into the filter element 41 and thereby the filter element 41 is filled with the fuel, liquid film of the fuel is formed at surfaces of the filter element 41. When the liquid film of the fuel is formed at the surfaces of the filter element 41, the fuel may pass through the filter element 41 but vapors (such as air) are prevented from passing through the filter element 41.

[0075] The filter element 41 is composed of a first element 42 arranged at an upper side (on a side toward the upper wall 26 of the fuel tank 24) and a second element 44 arranged at a lower side (on a side to the bottom wall 25 of the fuel tank 24). Each of the first and second elements 42 and 44 is formed of a thin film and overlapped in a vertical direction. An outer periphery of each element 42 and 44 is heated so that they are welded to each other to form the flat bag.

[0076] A part of the first element 42 is projected in an upward direction toward the upper wall 26 of the fuel tank 24. The connecting member 46, which communicates the inside and outside of the filter device 40 with each other, is provided to the first element 42 at a side to the electric pump 12. The connecting member 46 is connected to the suction port 20 of the electric pump 12. The first element 42 has a slope wall portion 42a, which is upwardly inclined toward the upper wall 26 of the fuel tank 24, so that a height of the slope wall portion 42a becomes larger as a distance from the connecting member 46 (namely, a distance from the electric pump 12) is larger. The first element 42 also has a flat wall portion 42b, which is formed at a side separated from the electric pump 12 and at which the valve device 60 is provided (explained below). The second element 44 is formed in a flat cylindrical shape having a bottom end facing to the bottom wall 25 of the fuel tank 24. The above two elements 42 and 44 are connected to each other to form the bag-shaped filter element 41, so that a fuel passage 50 and a vapor pooling chamber 51 are formed inside of the filter element 41.

[0077] The fuel passage 50 is formed on a side to the second element 44 so as to guide the fuel, which has passed through the filter element 41 and thereby has been filtered, toward the suction port 20 of the electric pump 12. The vapor pooling

chamber 51 is formed at an upper portion (above the fuel passage 50) of the inside space of the filter element 41 and communicated with the fuel passage 50. The vapor pooling chamber 51 pools vapors included in the filtered fuel flowing through the fuel passage 50. The vapor pooling chamber 51 is partly formed by the slope wall portion 42a and the flat wall portion 42b of the first element 42.

[0078] Vapors included in the filtered fuel will be explained. A vapor pressure curve of the fuel (for example, in which fuel alcohol is included gasoline) may become larger than that of gasoline fuel, depending on a content of fuel alcohol included in gasoline. A vapor pressure of the gasoline fuel at a certain temperature is higher than that of the fuel in which the fuel alcohol is included in the gasoline fuel to some extent. In addition, when temperature of the fuel becomes higher, the vapor pressure becomes higher.

[0079] As explained above, when the electric pump 12 is operated, the fuel suction force is generated at the electric pump 12. Therefore, the pressure of the fuel in the inside of the filter device 40 is decreased, when compared with the fuel pressure outside of the filter device 40, so that the fuel outside of the filter device 40 passes through the filter element 41.

[0080] However, since the fuel pressure inside of the filter device 40 is decreased to be lower than the fuel pressure outside of the filter device 40 as explained above, the fuel pressure inside of the filter device 40 may become lower than the vapor pressure of the fuel. Then, vapors may be generated in the filtered fuel, depending on the fuel pressure and/or fuel temperature inside of the filter device 40.

[0081] The filter frame 52 made of resin is provided in the fuel passage 50 and the vapor pooling chamber 51. Since the filter element 41 is made of the non-woven fabric, a mechanical strength is rather low. In a case that an outer shell of the filter device 40 is formed by the filter element 41, like the present embodiment, it may be difficult to hold a shape of the filter element 41 when any external force or pressure is applied to thereto. As a result, it may also become difficult to maintain the shapes of the fuel passage 50 and the vapor pooling chamber 51, both of which are provided inside of the filter device 40.

[0082] According to the present embodiment, however, the filter frame 52 is provided inside of the filter device 40. It is, therefore, possible to support an inner surface of the filter element 41, to thereby maintain the shape thereof. Even when the fuel pressure inside of the filter device 40 becomes lower than the fuel pressure outside of the filter device 40 because of the fuel suction force of the electric pump 12, and thereby a force (a pressure) is applied to the filter element 41 in a direction of pushing it toward the inside thereof, it is possible to keep the shape of the filter element 41. In other words, it is possible to keep the shapes of the fuel passage 50 and the vapor pooling chamber 51. Since the shape of the filter element 41 can be maintained by the filter frame 52, it may be possible to form almost all of the outer shell of the filter device 40 by the filter element 41. Thus, it is possible to increase filtering area of the filter device 40.

[0083] The valve device 60 is provided at the flat wall portion 42b. The valve device 60 operatively communicates the vapor pooling chamber 51 with the outside of the filter device 40, so that the vapors pooled in the vapor pooling chamber 51 may be discharged to the outside of the filter device 40.

[0084] The valve device 60 is composed of a valve seat member 61 and a valve body member 62. The valve seat

member 61 is made of resin and formed in a disc shape. The valve seat member 61 is attached to an aperture formed at the flat wall portion 42b. The valve seat member 61 has an annular seat portion 61a to which the valve body member 62 is seated and multiple communication holes 61b for communicating the vapor pooling chamber 51 to the outside of the filter device 40. The seat portion 61a is formed at an outer surface 61c of the valve seat member 61, wherein the outer surface 61c faces to the outside of the filter device 40. The communication holes 61b are formed at an inner area of the seat portion 61a.

[0085] The valve body member 62 is made of flexible material for opening and/or closing the communication holes 61b. The valve body member 62 is composed of an umbrella portion 62a arranged at an outside of the filter device 40 and a shaft portion 62b for attaching the umbrella portion 62a to the valve seat member 61. As shown in FIG. 2, the umbrella portion 62a is so formed that an outer peripheral portion thereof is seated on the annular seat portion 61a. The shaft portion 62b extends from a center of the umbrella portion 62a toward the valve seat member 61 and fixed thereto.

[0086] According to the valve device 60 of the above structure, when the vapors are pooled in the vapor pooling chamber 51, the vapors flow through the communication holes 61b into a space, which is formed between an inner surface of the umbrella portion 62a and the outer surface 61c of the valve seat member 61. When an amount of vapors in the above space exceeds a predetermined value, the vapors push up the umbrella portion 62a by buoyancy, in a direction that the outer peripheral portion of the umbrella portion 62a is separated from the annular seat portion 61a. When the umbrella portion 62a is lifted up and separated from the annular seat portion 61a, the vapors flow out of the filter device 40, as indicated by one-dot-chain lines in FIG. 2. The vapors pooled in the vapor pooling chamber 51 may be pushed by the fuel flowing into the filter element 41, so that some of the vapors may be additionally discharged out of the filter device 40 through the valve device 60.

[0087] When the amount of the vapors in the vapor pooling chamber 51 is reduced, the force for pushing up the umbrella portion 62a becomes smaller, so that the umbrella portion 62a tends to return to its initial condition, that is, an initial shape in which the umbrella portion 62a is seated on the annular seat portion 61a. Then, the umbrella portion 62a is finally seated on the annular seat portion 61a to shut off the communication between the inside and outside of the filter device 40. Therefore, when the fuel pressure outside of the filter device 40 is higher than the fuel pressure inside of the filter device 40, and thereby the fuel outside of the filter device 40 tends to flow into the inside of the filter device 40 through the valve device 60, a valve closed condition of the valve device 60 is maintained, because a force (a pressure) is applied to the umbrella portion 62a in a direction that the umbrella portion 62 is seated on the annular seat portion 61a. Accordingly, the fuel outside of the filter device 40 may not enter into the inside of the filter device 40 through the valve device 60.

[0088] As above, the valve device 60 allows the vapors to flow out from the vapor pooling chamber 51 to the outside of the filter device 40 on one hand, but prevents the fuel outside of the filter device 40 from flowing into the vapor pooling chamber 51.

[0089] The filter element 41 may form a part of the outer shell of the filter device 40. In other words, when the outer shell has the filter element 41 at least at a portion thereof, the

filter device 40 can perform its function. It is, however, preferable that all of the outer shell of the filter device 40 is formed by the filter element 41, like the present embodiment. Generally, a space for the filter device 40 is limited. It is possible to keep the filtering area as large as possible, when all of the outer shell of the filter device 40 is formed by the filter element 41.

[0090] An operation of the fuel supply device 11 will be explained. When the electric pump 12 is operated, the fuel suction force is generated. Then, since the fuel pressure inside of the filter device 40 becomes lower than the fuel pressure outside of the filter device 40, the fuel outside of the filter device 40 (in the fuel tank 24) passes through the filter element 41 and enters into the fuel passage 50. The fuel having entered into the fuel passage 50 flows into the pump portion 16 through the suction port 20. The fuel sucked into the pump portion 16 is pressurized in the pump portion 16 to be discharged from the outlet port 18.

[0091] The fuel discharged from the pump outlet port 18 flows into the space accommodating the electric motor 13 and then the fuel is pumped out through the discharge port 21 of the electric pump 12. The pressure of the fuel pumped out from the discharge port 21 is regulated by the pressure regulating device 22 and supplied to the engine 30 (outside of the fuel tank 24) through the fuel supply pipe 23.

[0092] Since the fuel pressure inside of the filter device 40 is decreased to be lower than the fuel pressure outside of the filter device 40 due to the fuel suction force, the vapors may be generated in the filtered fuel when the fuel passes through the filter element 41. The generated vapors are moved by the buoyancy within the filter device 40 toward the vapor pooling chamber 51 formed above the fuel passage 50, so that the vapors are pooled in the vapor pooling chamber 51. As above, the vapors are separated from the filtered fuel, which passed through the filter element 41 and entered into the fuel passage 50.

[0093] As shown in FIG. 2, the vapors generated within the filter element 41 are moved toward the valve device 60 along the slope wall portion 42a. The vapors are surely guided by the slope wall portion 42a toward the valve device 60.

[0094] According to the present embodiment, the slope wall portion 42a is provided in such a manner that the height of the slope wall portion 42a becomes larger as the distance from the connecting member 46 is longer. Therefore, when the vapors are moved along the slope wall portion 42a, the vapors are further separated from the connecting member 46. An effect for preventing the vapors from flowing into the suction port 20 can be thereby increased.

[0095] The filtered fuel, from which the vapors are separated, goes to the suction port 20 with a flow generated by the fuel suction force of the electric pump 12 as indicated by arrows with white color. The filtered fuel is then sucked into the electric pump 12.

[0096] If the vapors are included in the filtered fuel sucked into the electric pump 12, the electric pump 12 can not pump out the fuel of such amount, which at least corresponds to a cubic volume of the vapors. Therefore, the pump discharge amount is decreased, when compared with a case in which no vapor is included in the fuel sucked into the electric pump. According to the filter device 40 of the present embodiment, it is possible to separate the vapors from the filtered fuel within the filter device 40, to thereby suppress flow-in of the vapors into the suction port 20 of the electric pump 12. As a

result, it is possible to suppress a possible decrease of the pump discharge amount of the electric pump 12.

[0097] Since the pump discharge amount may be decreased, as explained above, when the vapors are included in the fuel to be sucked into the electric pump 12, it may become necessary to increase electric power supply amount to the electric pump 12 and thereby to increase rotational speed of the impeller in order to obtain a necessary pump discharge amount if the vapors are allowed to flow into the electric pump 12. In such a case, electric power consumption to the electric pump 12 may be increased, and it is against a power saving function required for a recent vehicle.

[0098] According to the filter device 40 of the present embodiment, however, since it is possible to suppress the possible decrease of the pump discharge amount of the electric pump 12, the necessary pump discharge amount can be obtained with smaller electric power to thereby contribute in the power saving for the vehicle. In addition, the electric pump 12 can be made smaller in size, because the electric power consumption thereof is decreased.

[0099] When the liquid film of the fuel is formed at the surfaces of the filter element 41, the vapors may not pass through the filter element 41. Therefore, the amount of vapors pooled in the vapor pooling chamber 51 is further increased.

[0100] When the amount of generated vapors exceeds a vapor accommodating capacity of the vapor pooling chamber 51, the vapors may overflow from the vapor pooling chamber 51 and may flow into the fuel passage 50. More exactly, when the vapor amount exceeds a lowermost line (a dotted line shown in FIG. 2) of the vapor pooling chamber 51, the vapors may flow into the fuel passage 50.

[0101] According to the present embodiment, the valve device 60 is provided at the filter device 40 for operatively communicating the vapor pooling chamber 51 with the outside of the filter device 40. When the vapor amount in the vapor pooling chamber 51 exceeds a predetermined amount, the vapors push up the umbrella portion 62a of the valve device 60 so that the vapors may flow out to the outside of the filter device 40. Since the slope wall portion 42a is provided in the filter element 41, the vapors are guided toward the valve device 60 so that the vapors are smoothly discharged to the outside of the filter device 40.

[0102] As above, the filter device 40 of the present embodiment has a structure, according to which the vapors in the vapor pooling chamber 51 are discharged to the outside of the filter device 40. It is, therefore, possible to suppress generation of the problem that the separated vapors may flow into the fuel passage 50. It is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount.

[0103] According to the present embodiment, since the slope wall portion 42a is formed by the filter element 41, the fuel flows into the filter element 41 at a portion lower than the vapors pooled in the vapor pooling chamber 51. The vapors in the vapor pooling chamber 51 may receive pressure from the fuel flowing into the filter element 41 and may be pushed out through the valve device 60. Thus, the vapors are effectively discharged to the outside of the filter device 40.

[0104] Since the slope wall portion 42a of the filter element 41 is upwardly inclined toward the valve device 60, the vapors can be surely guided toward the valve device 60 and immediately discharged to the outside of the filter device 40.

[0105] The valve device 60 has a structure for preventing the fuel from flowing into the vapor pooling chamber 51 from

the outside of the filter device 40. Therefore, the fuel always passes through the filter element 41. The valve device 60 prevents the fuel from entering into the inside of the filter element 41 without passing through the filter element 41, so that the filtered fuel can be always supplied into the electric pump 12.

Second Embodiment

[0106] A second embodiment of the present invention will be explained with reference to the drawings. The second embodiment is a modification of the first embodiment. According to the second embodiment, a shape of a filter device 140 is different from the filter device 40 of the first embodiment. The structures of the electric pump 12, the pressure regulating device 22 and the fuel supply pipe 23 are the same to those of the first embodiment. FIG. 3 is a schematic cross sectional view showing a fuel supply device 111 according to the second embodiment of the present invention (a cross sectional view taken along a line in FIG. 4). FIG. 4 is a top plan view of the fuel supply device 111 when viewed in a direction of an arrow IV in FIG. 3.

[0107] The filter device 140 of the fuel supply device 111 according to the present embodiment is composed of a filter element 141, a connecting member 146, a filter frame 152, a valve device 60 and so on. The filter element 141 is made of non-woven film sheets (made of resinous fiber) like the filter element 41 of the first embodiment. The filter element 141 is formed in such a bag shape, which covers an axial lower end of the electric pump 12 (at a side to the bottom surface 25 of the fuel tank 24) and at least partly an outer peripheral wall of the electric pump 12 in a radial direction. The filter element 141 traps the extraneous material contained in the fuel when the fuel passes through the filter element 141.

[0108] The filter element 141 is composed of a first element 142 arranged at an upper side (on the side toward the upper wall 26 of the fuel tank 24) and a second element 144 arranged at a lower side (on the side to the bottom wall 25 of the fuel tank 24). Each of the first and second elements 142 and 144 is formed of a thin film and overlapped in a vertical direction. An outer periphery of each element 142 and 144 is heated so that they are welded to each other to form the bag shape filter element 141.

[0109] The first element 141 is composed of a circular wall portion 142a, an inner cylindrical wall portion 142b, an upper wall portion 142c and an outer cylindrical portion 142d. The circular wall portion 142a is arranged at an axial lower end of the electric pump 12. The inner cylindrical wall portion 142b upwardly extends from an outer periphery of the circular wall portion 142a toward the upper wall 26 of the fuel tank 24 and partly covers at least the outer peripheral wall of the electric pump 12 in the radial direction. The outer cylindrical wall portion 142d is arranged at a distance from the inner cylindrical wall portion 142b in a radial direction. As shown in FIG. 4, the first element 142 has a C-shaped cross section. Although the inner and outer wall portions 142b and 142d are named as the cylindrical wall portions, respectively, a cross sectional figure thereof is a C-shape. Each of circumferential ends of the outer cylindrical wall portion 142d is connected to each of circumferential ends of the inner cylindrical wall portion 142b. Upper axial ends of the inner and outer cylindrical wall portions 142b and 142d are connected to the upper wall portion 142c of an arc shape (a C-shape).

[0110] As shown in FIG. 3, the second element 144 is formed in a flat cylindrical shape having a bottom end facing

to the bottom wall 25 of the fuel tank 24. The connecting member 146 is provided at the circular wall portion 142a. As shown in FIGS. 3 and 4, the valve device 60, which is identical to that of the first embodiment, is provided at the upper wall portion 142c, which is upwardly inclined toward the valve device 60. Therefore, the valve device 60 is provided at the upper wall portion 142c at such a position, which is highest in the vertical direction of the filter device 140.

[0111] The above two elements 142 and 144 are connected to each other to form the bag-shaped filter element 141, so that a fuel passage 150 and a vapor pooling chamber 151 are respectively formed inside of the filter element 141. More exactly, the fuel passage 150 is formed on a side to the bottom wall of the fuel tank 24 and the vapor pooling chamber 151 is formed at a space above the fuel passage 150 and surrounded by the inner cylindrical wall portion 142b, the upper wall portion 142c and the outer cylindrical wall portion 142d.

[0112] The filter frame 152 made of resin is provided in the fuel passage 150 and the vapor pooling chamber 151. The filter frame 152 is provided inside of the filter device 140 to support an inner surface of the filter element 141, to thereby maintain the shape thereof. Since the filter frame 152 is provided in the fuel passage 150 and the vapor pooling chamber 151, it is possible to keep the shape of the filter element 141, even when the fuel pressure inside of the filter element 141 becomes lower than the fuel pressure outside of the filter element 141 because of the fuel suction force of the electric pump 12, and thereby a force (a pressure) is applied to the filter element 141 in a direction of pushing it toward the inside thereof.

[0113] As in the same manner to the first embodiment, the filter element 141 exerts a function of an outer shell for the filter device 140. According to the second embodiment, almost all of the outer shell for the filter device 140 is likewise formed by the filter element 141.

[0114] An operation of the fuel supply device 111 will be explained. Since the electric pump 12 is identical to that of the first embodiment, flows of the fuel and the vapors in the filter device 140 will be mainly explained.

[0115] When the electric pump 12 is operated, the fuel suction force is generated. Then, the fuel passes through the filter element 141 and enters from the outside of the filter element 141 into the fuel passage 150. Since the fuel pressure inside of the filter device 140 is decreased to be lower than the fuel pressure outside of the filter device 140 due to the fuel suction force, the vapors may be generated in the filtered fuel when the fuel passes through the filter element 141. The vapors thus generated are moved by the buoyancy within the filter device 140 toward the vapor pooling chamber 151 formed above the fuel passage 150, so that the vapors are pooled in the vapor pooling chamber 151. As above, the vapors are separated from the filtered fuel, which passed through the filter element 141 and entered into the fuel passage 150.

[0116] Since the upper wall portion 142c is upwardly inclined toward the valve device 60, as already explained above, the vapors pooled in the vapor pooling chamber 151 are moved toward the valve device 60 along the inner surface of the upper wall portion 142c. According to the above inclined structure of the upper wall portion 142c, it is possible to effectively guide the vapors toward the valve device 60 and smoothly discharge the guided vapors to the outside of the filter device 140, as indicated by dotted arrows in FIG. 4.

[0117] The filtered fuel, from which the vapors are separated, goes to the suction port 20 with a flow generated by the fuel suction force of the electric pump 12 as indicated by arrows with white color in FIG. 3. The filtered fuel is then sucked into the electric pump 12.

[0118] According to the above structure, it is possible to separate the vapors from the filtered fuel within the filter device 140, to thereby suppress flow-in of the vapors into the suction port 20 of the electric pump 12. As a result, it is possible to suppress a possible decrease of the pump discharge amount of the electric pump 12.

[0119] When the vapor amount in the vapor pooling chamber 151 exceeds a predetermined amount, the vapors push up the umbrella portion 62a of the valve device 60 so that the vapors may flow out to the outside of the filter device 140. Accordingly, it is also possible to discharge the vapors in the vapor pooling chamber 151 to the outside of the filter device 140. As a result, it is possible to suppress generation of the problem that the separated vapors may flow into the fuel passage 150. It is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount.

Modification of Second Embodiment

[0120] A modification of the second embodiment will be explained with reference to the drawing. A position for the valve device 60 in the modification is different from the second embodiment. The electric pump 12, the pressure regulating device 22 and the fuel supply pipe 23 are identical to the first embodiment. FIG. 5 is a schematic enlarged cross sectional view showing a filter device 240 of a fuel supply device 211 according to the modification of the second embodiment. The other parts and/or portions, except for a valve device 160 forming a part of the filter device 240, are the same to the second embodiment.

[0121] According to the modification, the valve device 160 is provided at the outer cylindrical wall portion 142d of the first element 142, more exactly, at a portion of the radial side wall portion thereof. Like the valve device 60 of the first embodiment, the valve device 160 of the modification also allows the vapors to flow out from the vapor pooling chamber 151 out of the filter device 240, but prevents the fuel outside of the filter device 240 from flowing into the vapor pooling chamber 151.

Third Embodiment

[0122] A third embodiment of the present invention will be explained with reference to the drawings. According to the third embodiment, being different from the first and second embodiments, the outer shell of a filter device 340 is formed by a filter element 341a and a tank wall member 341b. The tank wall member 341b is made of resin and forms a wall which does not allow fluid (such as, the fuel and air) to pass therethrough. The structures of the electric pump 12, the pressure regulating device 22 and the fuel supply pipe 23 are the same to those of the first or second embodiment. FIG. 6 is a schematic cross sectional view showing a fuel supply device 311 according to the third embodiment of the present invention.

[0123] The filter device 340 of the fuel supply device 311 is composed of a filter portion 340a, a tank portion 340b, the valve device 60 and so on. The filter device 340 is arranged at a position, which is outside of the electric pump 12 in its radial direction.

[0124] An outer shell of the filter portion 340a is formed by the filter element 341a, which is made of non-woven film sheets (made of resinous fiber). The filter element 341a traps the extraneous material contained in the fuel when the fuel passes through the filter element 341a. The filter element 341a is formed in a flat bag extending along the bottom wall 25 of the fuel tank 24. Like the first or second embodiment, the filter element 341a is composed of a first and a second element, each of which is formed of a thin film and overlapped in a vertical direction. An outer periphery of each element is heated so that they are welded to each other to form the flat bag.

[0125] A first fuel passage 350a, into which the filtered fuel enters, is formed inside of the bag-shaped filter element 341a. Although not shown in FIG. 6, a filter frame corresponding to the filter frame 52 of the first embodiment is provided inside of the filter element 341a in order to maintain the shape thereof.

[0126] The tank portion 340b is provided above the filter portion 340a, to which the tank portion 340b is connected. The tank portion 340b is composed of the tank wall member 341b, a filter-side coupling portion 346a and a pump-side coupling portion 346b. The valve device 60 is provided at an upper portion of the tank portion 340b. The tank portion 340b not only supplies the fuel, which is filtered by the filter portion 340a, to the electric pump 12, but also pools the vapors generated when the fuel passes through the filter portion 340a.

[0127] The tank wall member 341b has an upper end wall 342, a lower end wall 343 and a side wall 344 and forms inside thereof a second fuel passage 350b and a vapor pooling chamber 351. The second fuel passage 350b is formed on a side to the lower end wall 343, while the vapor pooling chamber 351 is formed above the second fuel passage 350b. The vapor pooling chamber 351 is communicated with the second fuel passage 350b, so that the vapors included in the filtered fuel flowing through the second fuel passage 350b may be moved to the vapor pooling chamber 351, which is formed on a side to the upper end wall 342.

[0128] The filter-side coupling portion 346a connected to the filter portion 340a is formed at the lower end wall 343, so that the first fuel passage 350a of the filter portion 340a is communicated to the second fuel passage 350b of the tank portion 340b. The filtered fuel (passed through the filter element 341a) entering into the first fuel passage 350a flows into the second fuel passage 350b through the filter-side coupling portion 346a. In addition, the pump-side coupling portion 346b connected to the suction port 20 of the electric pump 12 is provided at the lower end wall 343, so that the second fuel passage 350b is communicated to the suction port 20. The filtered fuel entering into the second fuel passage 350b flows into the electric pump 12 through the pump-side coupling portion 346b and the suction port 20. The valve device 60 is provided at the upper end wall 342.

[0129] The valve device 60 has the same structure to that of the valve device of the first embodiment. According to the present embodiment, the valve seat member 61 is integrally formed with the upper end wall 342 of the tank portion 340b. Explanation for the other parts and/or portion of the valve device 60 is omitted.

[0130] An operation of the fuel supply device 311 will be explained. Since the operation of the electric pump 12 is

identical to that of the first or second embodiment, flows of the fuel and the vapors in the filter device 340 will be mainly explained.

[0131] When the electric pump 12 is operated, the fuel suction force is generated. Then, the fuel passes through the filter element 341a of the filter portion 340a and enters from the outside of the filter device 340 into the first fuel passage 350a. Since the fuel pressure inside of the filter portion 340a is decreased to be lower than the fuel pressure outside of the filter portion 340a due to the fuel suction force, the vapors may be generated in the filtered fuel when the fuel passes through the filter element 341a. The vapors thus generated are moved in the filter portion 340a together with fuel flowing in the first fuel passage 350a to the second fuel passage 350b. The vapors flow into the second fuel passage 350b together with the filtered fuel.

[0132] In the tank portion 340b, the vapors included in the filtered fuel having entered into the second fuel passage 350b are not moved together with the fuel flow (indicated by arrows with white color in FIG. 6) generated by the fuel suction force of the electric pump 12, but moved by the buoyancy upwardly toward the vapor pooling chamber 351 and pooled therein. As above, the vapors are separated from the filtered fuel, which passed through the filter element 341a and entered into the second fuel passage 350b.

[0133] The filtered fuel, from which the vapors are separated, goes to the suction port 20 through the pump-side coupling portion 346b with the fuel flow indicated by the arrows with white color (in FIG. 6), and then sucked into the electric pump 12.

[0134] According to the above structure, it is also possible to separate the vapors from the filtered fuel within the filter device 340 (in the tank portion 340b), to thereby suppress flow-in of the vapors into the suction port 20 of the electric pump 12. As a result, it is possible to suppress a possible decrease of the pump discharge amount of the electric pump 12.

[0135] When the vapor amount in the vapor pooling chamber 351 exceeds a predetermined amount, the vapors push up the umbrella portion 62a of the valve device 60 so that the vapors may flow out to the outside of the filter device 340. Accordingly, it is also possible to discharge the vapors in the vapor pooling chamber 351 to the outside of the filter device 340. As a result, it is possible to suppress generation of the problem that the separated vapors may flow into the second fuel passage 350b. It is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount.

[0136] According to the present embodiment, unlike the filter device 40 or 140 of the first or second embodiment, the filter device 340 has the tank portion 340b. According to such structure, it is possible to hold the fuel in the tank portion 340b, so long as the filter element 341a is soaked in the fuel, even in the case that fuel level is lowered in the fuel tank 24 and the fuel level around the filter device 340 becomes lower than the fuel level in the tank portion 340b.

[0137] This is because the tank portion 340b is made of the resin material, which does not allow the fuel or air to pass through the same, and because the valve device 60 provided at the upper portion of the tank portion 340b has a function for preventing the fuel (and/or air) from entering into the tank portion 340b from the outside thereof. For example, when the vehicle turns in a left or a right hand direction, centrifugal force is applied to the fuel and thereby the fuel is moved

toward one side in the fuel tank. In such a case, the fuel level around the filter device 340 may be lowered.

Modification of Third Embodiment

[0138] A modification of the third embodiment will be explained with reference to the drawing. A filter device 440 of the modification is different from the filter device 340 of the third embodiment in that an auxiliary jet pump 470 is provided between the tank portion 340b and the filter portion 340a. The auxiliary jet pump 470 subsidizes fuel supply into the tank portion 340b. The electric pump 12, the pressure regulating device 22 and the fuel supply pipe 23 in this modification are also identical to the first embodiment. FIG. 7 is a schematic cross sectional view showing a fuel supply device 411 according to the modification of the third embodiment. The auxiliary jet pump 470 will be mainly explained.

[0139] The auxiliary jet pump 470 generates fuel suction force and discharges the fuel (sucked from the first fuel passage 350a) into the second fuel passage 350b, in order to subsidize the fuel supply into the tank portion 340b. The auxiliary jet pump 470 is composed of a throat portion 471, a fuel jet portion 475 and so on. The throat portion 471 is a cylindrical member made of resin material and is formed in a cylindrical shape. The throat portion 471 has a fuel jet passage 471a, which communicates the first fuel passage 350a to the second fuel passage 350b. The throat portion 471 is connected to the tank portion 340b in such a way that a direction of the fuel jet passage 471a of the throat portion 471 is aligned with the vertical direction of the fuel tank 24. More exactly, the throat portion 471 is supported by an aperture 346c formed at the lower end wall 343 of the tank portion 340b, so that an upper open end 471b of the throat portion 471 is arranged inside of the second fuel passage 350b, while a lower open end 471c is arranged outside of the tank portion 340b. The lower open end 471c of the throat portion 471 is connected to the filter portion 340a, so that the fuel jet passage 471a is communicated to the first fuel passage 350a of the filter portion 340a. As shown in FIG. 7, the fuel jet passage 471a has a small-diameter passage portion, at which an inner wall is elevated toward a center of the fuel jet passage 471a. [0140] The fuel jet portion 475 is provided in the fuel jet passage 471a below the small-diameter passage portion and jets out the surplus fuel (which is discharged from the pressure regulating device 22) toward the upper open end 471b. A fuel pipe 476 is connected to the fuel jet portion 475, so that the surplus fuel is supplied to the fuel jet portion 475 from the pressure regulating device 22.

[0141] In the above modification, the surplus fuel from the pressure regulating device 22 is supplied to the fuel jet portion 475. However, any other system may be applied to the present invention. For example, a part of fuel, which is supplied to the engine 30 but not consumed for combustion in the engine 30 and finally returned to the fuel tank 24, and which is different from the surplus fuel from the pressure regulating device 22, may be supplied to the fuel jet portion 475. More exactly, the fuel discharged from a vapor discharge port (not shown) of the pump portion 16 may be supplied to the fuel jet portion 475, or return fuel from the engine 30 may be supplied to the fuel jet portion 475.

[0142] An operation of the fuel supply device 411 will be explained. When the electric pump 12 is operated, the fuel suction force is generated. Due to the fuel suction force, the fuel in the inside of the tank portion 340b flows into the electric pump 12 through the pump-side coupling portion

346b. Then, the fuel is pressurized and discharged from the discharge port **21** of the electric pump **12** to the pressure regulating device **22**. Fuel pressure of the fuel supplied to the pressure regulating device **22** is adjusted and supplied to the engine **30**.

[0143] The surplus fuel discharged from the pressure regulating device **22** is supplied to the fuel jet portion **475** through the fuel pipe **476**, so that the surplus fuel is emitted from the fuel jet portion **475**. As a result, fuel pressure around the fuel jet portion **475** is decreased to be lower than the fuel pressure in the first fuel passage **350a** to generate the fuel suction force. Due to the fuel suction force, the fuel pressure in the first fuel passage **350a** becomes lower than the fuel pressure outside of the filter portion **340a**, and thereby the fuel outside of the filter portion **340a** passes through the filter element **341a** to enter into the first fuel passage **350a**.

[0144] The fuel entered into the first fuel passage **350a** flows into the fuel jet passage **471a** from its lower open end **471c** of the throat portion **471**, as indicated by arrows with white color in FIG. 7. The fuel is discharged from the upper open end **471b** of the throat portion **471** together with the fuel emitted from the fuel jet portion **475**. As above, the fuel sucked by the auxiliary jet pump **470** flows into the second fuel passage **350b** of the tank portion **340b**.

[0145] According to the modification, in the same or similar manner to the third embodiment, vapors may be generated in the filtered fuel when the fuel passes through the filter element **341a**. The filtered fuel including the vapors flows into the second fuel passage **350b** through the throat portion **471**. The vapors having entered into the second fuel passage **350b** are moved by the buoyancy upwardly toward the vapor pooling chamber **351** and pooled therein. As above, the vapors are separated from the filtered fuel having entered into the second fuel passage **350b**. The filtered fuel, from which the vapors are separated, goes to the suction port **20** through the pump-side coupling portion **346b** with the fuel flow indicated by the arrows with white color (in FIG. 7), and then sucked into the electric pump **12**.

[0146] According to the modification, since the auxiliary jet pump **470** is provided in the filter device **440**, the fuel is forcibly drawn from the first fuel passage **350a** to the second fuel passage **350b** (namely, into the tank portion **340b**). Then, the fuel pooled in the vapor pooling chamber **351** is discharged to the outside of the tank portion **340b** through the valve device **60**, wherein the vapors are pushed out by the fuel drawn up into the tank portion **340b**. As above, it is possible, according to the modified filter device **440**, to smoothly discharge the vapors pooled in the vapor pooling chamber **351**.

[0147] Since the structure of the tank portion **340b** is the same to that of the third embodiment, the filter device **440** of the modification has a function of pooling the fuel in the tank portion **340b**.

[0148] The modification (FIG. 7) is different from the third embodiment (FIG. 6) in that the auxiliary jet pump **470** is provided. The auxiliary jet pump **470** is operated so long as the electric pump **12** is in operation. According to such structure, it is possible to fill the tank portion **340b** with the fuel. Therefore, it is possible to hold the fuel in the tank portion **340b**, so long as the filter element **341a** is soaked in the fuel, even when the fuel level is lowered in the fuel tank **24** (and thereby the fuel level around the filter device **440** becomes lower than the fuel level in the tank portion **340b**) as a result that total fuel amount in the fuel tank **24** is decreased or the

fuel is moved toward one side in the fuel tank **24** during turning movement of the vehicle.

Fourth Embodiment

[0149] A fourth embodiment of the present invention will be explained with reference to the drawings. According to the fourth embodiment, the basic idea and structure of the first embodiment, that is, the vapors generated when the fuel passes through the filter element **41** are separated from the fuel in the filter device **40** and the pooled vapors are discharged to the outside of the filter device **40**, is applied to a suction pump device **570** for sucking the fuel and discharging the fuel into a tank device **580** of a fuel supply device **511**.

[0150] The fuel supply device **511** according to the fourth embodiment is composed of the electric pump **12**, the tank device **580**, the suction pump device **570** and so on. The electric pump **12**, the pressure regulating device **22** and the fuel supply pipe **23** are the same to those of the first to third embodiments. FIG. 8 is a schematic cross sectional view showing the fuel supply device **511** having the suction pump device **570** according to the fourth embodiment of the present invention.

[0151] The tank device **580** is a device for storing the fuel, which will be sucked into the electric pump **12**, and is arranged at a position, which is outside of the electric pump **12** in its radial direction. The tank device **580** is made of resin material and has an upper end wall **581**, a lower end wall **582**, and a side wall **583**, to form a fuel storing chamber **584** therein. An aperture **581a** is formed at the upper end wall **581**. A filter **581b**, which is made of resin fabric and formed in a sheet shape, is provided at the aperture **581a**. The filter **581b** is made of an open mesh for preventing relatively large extraneous material, which may fall down from a portion above the tank device **580** toward the bottom wall **25** of the fuel tank **24**, from entering into the tank device **580**. Since the filter **581b** is coarse-grained, not only the fuel but the air (vapors) may flow through the filter **581b**.

[0152] In the same manner to the third embodiment, a pump-side coupling portion **582a**, which is connected to the suction port **20** of the electric pump **12**, is provided at the lower end wall **582**. The fuel storing chamber **584** is thereby communicated to the suction port **20**, so that the fuel in the fuel storing chamber **584** flows into the electric pump **12** through the pump-side coupling portion **582a** and the suction port **20**. Another aperture **582b**, to which the suction pump device **570** is connected, is formed at the lower end wall **582**. The fuel sucked by the suction pump device **570** through the aperture **582b** flows into the fuel storing chamber **584**.

[0153] The suction pump device **570** is a pump device which draws the fuel into the fuel storing chamber **584** of the tank device **580** by use of the surplus fuel discharged from the pressure regulating device **22**. The suction pump device **570** is so designed that its suction amount is larger than the amount of the fuel which will be sucked into the electric pump **12** through the suction port **20**. The suction amount of the suction pump device **570** means a maximum fuel amount, which can be sucked and discharged into the fuel storing chamber **584** by the suction pump device **570**. As a result, the fuel pressure in the fuel storing chamber **584** becomes higher than the fuel pressure outside of the tank device **580**. Therefore, the fuel in the fuel storing chamber **584** is pushed out from the tank device **580** through the aperture **581a** formed at

the upper end wall **581**. A fuel condition in the fuel storing chamber **584** in the above situation is called as a positive pressure condition.

[0154] The suction pump device **570** is composed of a suction jet pump **571**, a filter device **540** and so on. The suction jet pump **571** operates in the same manner to the auxiliary jet pump **470** of the third embodiment. The suction jet pump **571** generates the fuel suction force to suck fuel from a fuel passage **550** formed inside of the filter device **540** and discharges the sucked fuel into the fuel storing chamber **584**.

[0155] The suction jet pump **571** is composed of a throat portion **572**, a fuel jet portion **574** and so on. The throat portion **572** is a cylindrical member made of resin material and is formed in a cylindrical shape. The throat portion **572** has a fuel jet passage **572a**, which communicates the fuel passage **550** to the fuel storing chamber **584**. The throat portion **572** is connected to the tank device **580** in such a way that a direction of the fuel jet passage **572a** of the throat portion **572** is aligned with the vertical direction of the fuel tank **24**. More exactly, the throat portion **572** is supported by the aperture **582b** formed at the lower end wall **582** of the tank device **580**, so that an upper open end **572b** of the throat portion **572** is arranged inside of the fuel storing chamber **584**, while a lower open end **572c** is arranged outside of the tank device **580**. The lower open end **572c** of the throat portion **572** is connected to the filter device **540**, so that the fuel jet passage **572a** is communicated to the fuel passage **550** of the filter device **540**. As shown in FIG. 8, the fuel jet passage **572a** has a small-diameter passage portion, at which an inner wall is elevated toward a center of the fuel jet passage **572a**.

[0156] The fuel jet portion **574** is provided in the fuel jet passage **572a** below the small-diameter passage portion and jets out the surplus fuel (which is discharged from the pressure regulating device **22**) toward the upper open end **572b**. A fuel pipe **576** is connected to the fuel jet portion **574**, so that the surplus fuel is supplied to the fuel jet portion **574** from the pressure regulating device **22**.

[0157] In the above modification, the surplus fuel from the pressure regulating device **22** is supplied to the fuel jet portion **574**. However, any other system may be applied to the present invention. For example, a part of fuel, which is supplied to the engine **30** but not consumed for combustion in the engine **30** and finally returned to the fuel tank **24**, and which is different from the surplus fuel from the pressure regulating device **22**, may be supplied to the fuel jet portion **574**. More exactly, the fuel discharged from a vapor discharge port (not shown) of the pump portion **16** may be supplied to the fuel jet portion **574**, or return fuel from the engine **30** may be supplied to the fuel jet portion **574**.

[0158] The filter device **540** is connected to the lower open end **572c** of the suction jet pump **571** so as to trap extraneous material included in the fuel to be sucked into the suction jet pump **571** through the lower open end **572c**. The filter device **540** is composed of a filter element **541**, the valve device **60** and so on. The filter element **541** is made of non-woven film sheets (made of resinous fiber) and formed in a flat bag extending along the bottom wall **25** of the fuel tank **24**. The filter element **541** traps the extraneous material contained in the fuel when the fuel passes through the filter element **541**.

[0159] The filter element **541** is composed of a first element **542** arranged at an upper side (on a side toward the upper wall **26** of the fuel tank **24**) and a second element **544** arranged at

a lower side (on a side to the bottom wall **25** of the fuel tank **24**). Each of the first and second elements **542** and **544** is formed of a thin film and overlapped in a vertical direction. An outer periphery of each element **542** and **544** is heated so that they are welded to each other to form the flat bag.

[0160] A part of the first element **542** is projected in an upward direction toward the upper wall **26** of the fuel tank **24**. A right-hand end of the first element **542** is connected to the lower open end **572c** of the suction jet pump **571**. The first element **542** has a slope wall portion **542a**, which is upwardly inclined toward the upper wall **26** of the fuel tank **24**, so that a height of the slope wall portion **542a** becomes larger as a distance from the right-hand end (namely, a distance from the suction jet pump **571**) is larger. The first element **542** also has a flat wall portion **542b**, which is formed at a side separated from the suction jet pump **571** and at which the valve device **60** (which is identical to that of the first embodiment) is provided.

[0161] The second element **544** is formed in a flat cylindrical shape having a bottom end facing to the bottom wall **25** of the fuel tank **24**. A right-hand end of the second element **544** is connected to the lower open end **572c** of the suction jet pump **571**. The above two elements **542** and **544** are connected to each other to form the bag-shaped filter element **541**, so that the fuel passage **550** and a vapor pooling chamber **551** are formed inside of the filter element **541**.

[0162] The fuel passage **550** is formed on a side to the second element **544** so as to guide the fuel, which has passed through the filter element **541** and thereby has been filtered, toward the suction jet pump **571**. The vapor pooling chamber **551** is formed at an upper portion (above the fuel passage **550**) of the inside space of the filter element **541** and communicated with the fuel passage **550**. The vapor pooling chamber **551** is partly formed by the slope wall portion **542a** and the flat wall portion **542b** of the first element **542**, like the first embodiment.

[0163] Since the valve device **60** is identical to that of the first embodiment, the explanation thereof is omitted. A filter frame (not shown) is provided in the filter element **541** for maintaining the shape of the filter element **541**, in the same manner to the first embodiment.

[0164] An operation of the fuel supply device **511** will be explained. When the electric pump **12** is operated, the fuel suction force is generated. Due to the fuel suction force, the fuel in the fuel storing chamber **584** of the tank device **580** flows into the electric pump **12** through the pump-side coupling portion **582a**. Then, the fuel is pressurized and discharged from the discharge port **21** of the electric pump **12** to the pressure regulating device **22**. Fuel pressure of the fuel supplied to the pressure regulating device **22** is adjusted and supplied to the engine **30**. The surplus fuel discharged from the pressure regulating device **22** is supplied to the fuel jet portion **574** through the fuel pipe **576**, so that the surplus fuel is emitted from the fuel jet portion **574**.

[0165] When the surplus fuel is emitted from the fuel jet portion **574**, fuel pressure around the fuel jet portion **574** is decreased to be lower than the fuel pressure in the filter device **540** to generate the fuel suction force. Due to the fuel suction force, the fuel pressure in the filter device **540** becomes lower than the fuel pressure outside of the filter device **540**, and thereby the fuel outside of the filter device **540** passes through the filter element **541** to enter into the fuel passage **550**. The vapors maybe generated in the filtered fuel when the fuel passes through the filter element **541**. The vapors thus gener-

ated are moved in the filter device 540 by the buoyancy upwardly toward the vapor pooling chamber 551 formed above the fuel passage 550 and pooled therein. As above, the vapors are separated from the filtered fuel having entered into the fuel passage 550.

[0166] The filtered fuel, from which the vapors are separated, goes to the lower open end 572c of the throat portion 572 along with the fuel flow formed by the fuel suction force generated at the suction jet pump 571, as indicated by the arrows with white color in FIG. 8, and then sucked into the fuel jet passage 572a of the suction jet pump 571. The fuel sucked into the fuel jet passage 572a is then discharged from the upper open end 572b of the throat portion 572 into the fuel storing chamber 584 together with the fuel emitted from the fuel jet portion 574.

[0167] As above, the suction jet pump 571 decreases the fuel pressure around the fuel jet portion 574 by emitting the fuel therefrom, to thereby generate the fuel suction force. When the fuel suction force becomes lower, the amount of the fuel discharged from the suction jet pump 571 becomes smaller. In addition, when the vapors are included in the fuel flowing into the suction jet pump 571 or in the fuel emitted from the fuel jet portion 574, the fuel pressure around the fuel jet portion 574 may not be sufficiently decreased. As a result, the fuel suction force to be generated by the suction jet pump 571 may be decreased.

[0168] According to the filter device 540 of the present embodiment, since the vapors included in the filtered fuel can be separated from the filtered fuel in the filter device 540, it is possible to suppress the flow-in of the vapors into the suction jet pump 571 to thereby suppress a possible decrease of the pump discharge amount of the suction jet pump 571.

[0169] As explained above, when the fuel including the vapors flows into the suction jet pump 571, the pump discharge amount of the suction jet pump 571 may be decreased to be lower than that of the case in which the fuel including no vapors flows into the suction jet pump 571. In such a case, it is necessary to supply a larger amount of the surplus fuel, in order to obtain the necessary pump discharge amount. Then, it is necessary to increase a pump discharging performance of the electric pump 12, in order to obtain the larger amount of the surplus fuel. As above, the electric power consumption at the electric pump 12 should be increased, which may prevent power saving for the vehicle.

[0170] According to the filter device 540 of the present embodiment, however, since the decrease of the pump discharge amount of the fuel jet pump 571 can be suppressed, it is possible to obtain the necessary pump discharge amount with a smaller amount of the surplus fuel. As a result, the electric power saving can be realized for the electric pump 12. In addition, the electric pump 12 can be made smaller in size, because of the decrease of the electric power consumption.

[0171] When the vapor amount in the vapor pooling chamber 551 exceeds a predetermined amount, the vapors push up the umbrella portion 62a of the valve device 60 so that the vapors may flow out to the outside of the filter device 540. Accordingly, it is also possible to discharge the vapors in the vapor pooling chamber 551 to the outside of the filter device 540. As a result, it is possible to suppress generation of the problem that the separated vapors may flow into the fuel passage 550. It is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount.

[0172] According to the present embodiment, the fuel storing chamber 584 is maintained in the positive pressure con-

dition, so long as the suction jet pump 571 is in operation. Therefore, it is possible to fill the fuel storing chamber 584 of the tank device 580 with the fuel, even when the electric pump 12 is operated in order to draw the fuel into the electric pump 12. The electric pump 12 can draw the fuel from the fuel storing chamber 584, even in the case that the fuel level around the suction pump device 570 becomes lower as a result that the total fuel amount is reduced or the fuel is moved to one side of the fuel tank 24 due to the turning movement of the vehicle. This is because the tank device 580 can be filled with the fuel and such filled fuel can be held in the tank device 580. It is, therefore, possible to avoid a situation that the fuel supply to the engine 30 may not be sufficiently done.

[0173] According to the tank device 580 of the present embodiment, the aperture 581a is provided at the upper end wall 581. Therefore, even in the case that the suction jet pump 571 draws the vapors and discharges them into the fuel storing chamber 584, the vapors having entered into the fuel storing chamber 584 are upwardly moved by the buoyancy toward the aperture 581a. The vapors are then upwardly pushed out by the fuel discharged from the suction pump device 570 and discharged to the outside of the tank device 580 through the filter 581b provided at the aperture 581a.

Modification of Fourth Embodiment

[0174] A modification of the fourth embodiment will be explained with reference to the drawing. The modification of the fourth embodiment is different from the fourth embodiment in that the vapors are discharged from the vapor pooling chamber 551 of the filter device 540 not to the outside of the fuel storing chamber 584 but into the fuel storing chamber 584. The electric pump 12, the pressure regulating device 22 and the fuel supply pipe 23 are the same to those of the first to fourth embodiments. FIG. 9 is a schematic cross sectional view showing a fuel supply device 611 according to the modification of the fourth embodiment. Different features from the fourth embodiment will be mainly explained.

[0175] An aperture 582c for supporting a valve device 660 is provided at the lower end wall 582 of the tank device 580, in addition to the pump-side coupling portion 582a and the aperture 582b. A suction pump device 670 is composed of the suction jet pump 571, the filter device 540 and so on. The suction jet pump 571 generates the fuel suction force to suck fuel from the fuel passage 550 formed inside of the filter device 540 and discharges the sucked fuel into the fuel storing chamber 584.

[0176] The suction jet pump 571 is composed of the throat portion 572, a fuel jet portion 575 and so on. The throat portion 572 is a cylindrical member made of resin material and is formed in a cylindrical shape. The throat portion 572 has the fuel jet passage 572a, which communicates the fuel passage 550 to the fuel storing chamber 584. The throat portion 572 is connected to the tank device 580 in such a way that the direction of the fuel jet passage 572a of the throat portion 572 is aligned with the vertical direction of the fuel tank 24. More exactly, the throat portion 572 is supported by the aperture 582b formed at the lower end wall 582 of the tank device 580, so that the upper open end 572b of the throat portion 572 is arranged inside of the fuel storing chamber 584, while the lower open end 572c is arranged outside of the tank device 580. The lower open end 572c of the throat portion 572 is connected to the filter device 540, so that the fuel jet passage 572a is communicated to the fuel passage 550 of the filter device 540. As shown in FIG. 9, the fuel jet

passage **572a** has a small-diameter passage portion, at which an inner wall is elevated toward a center of the fuel jet passage **572a**.

[0177] The fuel jet portion **575** is provided in the fuel jet passage **572a** below the small-diameter passage portion and jets out the surplus fuel (which is discharged from the pressure regulating device **22**) toward the upper open end **572b**. The fuel pipe **576** is connected to the fuel jet portion **575**, so that the surplus fuel is supplied to the fuel jet portion **575** from the pressure regulating device **22**.

[0178] In the above modification, the surplus fuel from the pressure regulating device **22** is supplied to the fuel jet portion **575**. However, any other system may be applied to the present invention. For example, a part of fuel, which is supplied to the engine **30** but not consumed for combustion in the engine **30** and finally returned to the fuel tank **24**, and which is different from the surplus fuel from the pressure regulating device **22**, maybe supplied to the fuel jet portion **575**. More exactly, the fuel discharged from a vapor discharge port (not shown) of the pump portion **16** may be supplied to the fuel jet portion **575**, or return fuel from the engine **30** may be supplied to the fuel jet portion **575**.

[0179] The filter device **540** is connected to the lower open end **572c** of the suction jet pump **571** so as to trap extraneous material included in the fuel to be sucked into the suction jet pump **571** through the lower open end **572c**. The filter device **540** is composed of the filter element **541**, the valve device **660** and so on. The filter element **541** is made of non-woven film sheets (made of resinous fiber) and formed in the flat bag extending along the bottom wall **25** of the fuel tank **24**. The filter element **541** traps the extraneous material contained in the fuel when the fuel passes through the filter element **541**.

[0180] The filter element **541** is composed of the first element **542** arranged at an upper side (on the side toward the upper wall **26** of the fuel tank **24**) and the second element **544** arranged at the lower side (on the side to the bottom wall **25** of the fuel tank **24**). Each of the first and second elements **542** and **544** is formed of the thin film and overlapped in the vertical direction. The outer periphery of each element **542** and **544** is heated so that they are welded to each other to form the flat bag.

[0181] The part of the first element **542** is projected in the upward direction toward the upper wall **26** of the fuel tank **24**. A left-hand end of the first element **542** is connected to the lower open end **572c** of the suction jet pump **571**. The first element **542** has the slope wall portion **542a**, which is upwardly inclined toward the upper wall **26** of the fuel tank **24**, so that the height of the slope wall portion **542a** becomes larger as the distance from the left-hand end (namely, the distance from the suction jet pump **571**) is larger. An upper open end of the first element **542**, which is formed at the side separated from the suction jet pump **571**, is connected to a valve seat member **661** (explained below) of the valve device **660**.

[0182] The second element **544** is formed in a flat cylindrical shape having a bottom end facing to the bottom wall **25** of the fuel tank **24**. A left-hand end of the second element **544** is connected to the lower open end **572c** of the suction jet pump **571**. The above two elements **542** and **544** are connected to each other to form the bag-shaped filter element **541**, so that the fuel passage **550** and the vapor pooling chamber **551** are formed inside of the filter element **541**.

[0183] The fuel passage **550** is formed on the side to the second element **544** so as to guide the fuel, which has passed

through the filter element **541** and thereby has been filtered, toward the suction jet pump **571**. The vapor pooling chamber **551** is formed at the upper portion (above the fuel passage **550**) of the inside space of the filter element **541** and communicated with the fuel passage **550**. The vapor pooling chamber **551** is partly formed by the slope wall portion **542a**, like the filter device **40** of the first embodiment.

[0184] The valve device **660** is composed of the valve seat member **661** and a valve body member **662**. The valve seat member **661** is formed in a cylindrical shape having an open end (a lower open end) and a closed end (an upper closed end) **661c**, wherein the lower open end is opened to the fuel passage **550**, while the upper closed end is arranged in the fuel storing chamber **584**. The valve seat member **661** is supported by an aperture **582c** of the tank device **580**, so that the lower open end is arranged at the outside of the filter device **540**.

[0185] The valve seat member **661** has an annular seat portion **661a** to which the valve body member **662** is seated and multiple communication holes **661b** for communicating the vapor pooling chamber **551** to the outside of the filter device **540** (more exactly, to the fuel storing chamber **584**). The seat portion **661a** is formed at the upper closed end portion **661c** of the valve seat member **661**. The communication holes **661b** are formed at an inner area of the seat portion **661a**.

[0186] The valve body member **662** is made of flexible material for opening and/or closing the communication holes **661b**. The valve body member **662** is composed of an umbrella portion **662a** arranged at an outside of the filter device **540** and a shaft portion **662b** for attaching the umbrella portion **662a** to the valve seat member **661**. As shown in FIG. 9, the umbrella portion **662a** is so formed that an outer peripheral portion thereof is seated on the annular seat portion **661a**. The shaft portion **662b** extends from a center of the umbrella portion **662a** toward the valve seat member **661** and fixed thereto.

[0187] According to the valve device **660** of the above structure, when the vapors are pooled in the vapor pooling chamber **551**, the vapors flow through the communication holes **661b** into a space, which is formed between an inner surface of the umbrella portion **662a** and an outer surface of the valve seat member **661**. When an amount of vapors in the above space exceeds a predetermined value, the vapors push up the umbrella portion **662a** by the buoyancy thereof, in a direction that the outer peripheral portion of the umbrella portion **662a** is separated from the annular seat portion **661a**. When the umbrella portion **662a** is lifted up and separated from the annular seat portion **661a**, the vapors flow out of the filter device **540**.

[0188] When the amount of the vapors in the vapor pooling chamber **551** is reduced, the force for pushing up the umbrella portion **662a** becomes smaller, so that the umbrella portion **662a** tends to return to its initial condition, that is, an initial shape in which the umbrella portion **662a** is seated on the annular seat portion **661a**. Accordingly, the fuel outside of the filter device **540** may not enter into the vapor pooling chamber **551** through the valve device **660**.

[0189] As above, the valve device **660** allows the vapors to flow out from the vapor pooling chamber **551** out of the filter device **540** on one hand, but prevents the fuel outside of the filter device **540** from flowing into the vapor pooling chamber **551**.

[0190] A filter frame (not shown) is provided in the filter element 541 for maintaining the shape of the filter element 541, in the same manner to the first embodiment (the filter frame 52).

[0191] An operation of the fuel supply device 611 will be explained. When the electric pump 12 is operated, the surplus fuel from the pressure regulating device 22 is supplied to the suction jet pump 571, so that the surplus fuel is discharged from the fuel jet portion 575 of the suction jet pump 571. Then, the fuel pressure around the fuel jet portion 575 becomes lower than the fuel pressure in the fuel passage 550, to thereby generate the fuel suction force.

[0192] Since, due to the fuel suction force, the fuel pressure in the filter device 540 becomes lower than the fuel pressure outside of the filter device 540, the fuel outside of the filter device 540 passes through the filter element 541 to enter into the fuel passage 550. The vapors may be generated in the filtered fuel when the fuel passes through the filter element 541. The vapors thus generated are moved in the filter device 540 by the buoyancy upwardly toward the vapor pooling chamber 551 formed above the fuel passage 550 and pooled therein. As above, the vapors are separated from the filtered fuel having entered into the fuel passage 550.

[0193] The filtered fuel, from which the vapors are separated, goes to the lower open end 572c of the throat portion 572 along with the fuel flow formed by the fuel suction force generated at the suction jet pump 571, as indicated by the arrows with white color in FIG. 9, and then sucked into the fuel jet passage 572a of the suction jet pump 571. The fuel sucked into the fuel jet passage 572a is then discharged from the upper open end 572b of the throat portion 572 into the fuel storing chamber 584 together with the fuel emitted from the fuel jet portion 575.

[0194] When the vapor amount in the vapor pooling chamber 551 exceeds a predetermined amount, the vapors are discharged to the outside of the filter device 540 through the valve device 660. The vapors discharged through the valve device 660 flow into the fuel storing chamber 584, and then the vapors are upwardly moved by the buoyancy toward the aperture 581a of the tank device 580. The vapors around the aperture 581a are pushed out by the fuel supplied from the suction pump device 670 through the filter 581b of the aperture 581a, and finally discharged to the outside of the tank device 580.

Fifth Embodiment

[0195] A fifth embodiment of the present invention will be explained with reference to the drawings. The fifth embodiment is different from the fourth embodiment in that a fuel tank 724 is formed in a saddle shape having a pair of (first and second) fuel chambers 728 and 729, and a fuel transfer pump 770 is provided instead of the suction pump device 570 (the fourth embodiment shown in FIG. 9) for transferring the fuel one of the fuel chambers (729) to the other fuel chamber 728.

[0196] FIG. 10 is a schematic view showing a fuel supply system 710 incorporating the fuel transfer pump 770 according to the fifth embodiment of the present invention. The fuel supply system 710 is provided in the fuel tank 724 of the so-called saddle-type. The saddle-type fuel tank 724 has a hollow portion 727, at which a part of a bottom wall 725 is elevated toward an upper wall 726. In a four wheel driven vehicle or a front-engine rear-driven vehicle (so-called an FR type vehicle), a propeller shaft 27 is arranged in the hollow

portion 727. The first and second fuel chambers 728 and 729 for storing the fuel are formed at both sides of the hollow portion 727.

[0197] The fuel supply system 710 is composed of a fuel supply device 711, the pressure regulating device 22, the fuel supply pipe 23, the fuel transfer pump 770 and so on. The fuel supply device 711, which has the electric pump 12 therein, is provided in the first fuel chamber 728. The fuel supply device 711 draws the fuel from the first fuel chamber 728 by the fuel suction force generated by the electric pump 12, pressurizes the fuel, and discharges the fuel to the pressure regulating device 22 provided in the fuel supply pipe 23.

[0198] The pressure regulating device 22 provided in the fuel supply pipe 23 adjusts the fuel pressure of the fuel from the fuel supply device 711 and supplies the fuel to the engine 30. The surplus fuel, which is generated at the pressure regulating device 22 when adjusting the fuel pressure (as explained in the first embodiment), is supplied to the fuel transfer pump 770 (explained below).

[0199] FIG. 11 is a schematic cross sectional view showing the fuel transfer pump 770. The fuel transfer pump 770 is provided in the second fuel chamber 729 in order to transfer the fuel from the second fuel chamber 729 to the first fuel chamber 728 by use of the surplus fuel from the pressure regulating device 22, so that the fuel of the second fuel chamber 729 is sucked into the fuel supply device 711.

[0200] The fuel transfer pump 770 is composed of a fuel-transfer jet pump 771, a filter device 740 and so on. The fuel-transfer jet pump 771 operates in the same manner to the suction jet pump 571 of the fourth embodiment (FIG. 8). The fuel-transfer jet pump 771 generates the fuel suction force so as to draw the fuel from a fuel passage 750 formed in the filter device 740, and then transfers such sucked fuel to the first fuel chamber 728. The fuel-transfer jet pump 771 is composed of a throat portion 772, a fuel transfer pipe 773, a fuel jet portion 775 and so on.

[0201] The throat portion 772 is a cylindrical member made of resin material and is formed in a cylindrical shape. The throat portion 772 has a fuel jet passage 772a. The throat portion 772 is provided in the second fuel chamber 729 in such a way that a direction of the fuel jet passage 772a of the throat portion 772 is aligned with the vertical direction of the fuel tank 724. One end of the fuel transfer pipe 773 is connected to an upper open end 772b of the throat portion 772. A fuel transfer passage 773a, which is communicated to the first fuel chamber 728, is formed inside of the fuel transfer pipe 773. As a result, the fuel jet passage 772a is communicated with the fuel transfer passage 773a (as shown in FIG. 11).

[0202] The other end 773b of the fuel transfer pipe 773 (which is an open end of the fuel transfer passage 773a at an opposite side of the throat portion 772) is opened to the first fuel chamber 728.

[0203] The filter device 740 is connected to a lower open end 772c of the throat portion 772, so that the fuel jet passage 772a is communicated to the fuel passage 750 formed inside of the filter device 740. As shown in FIG. 11, the fuel jet passage 772a has a small-diameter passage portion, at which an inner wall is elevated toward a center of the fuel jet passage 772a.

[0204] The fuel jet portion 775 is provided in the fuel jet passage 772a below the small-diameter passage portion and jets out the surplus fuel (which is discharged from the pressure regulating device 22) toward the upper open end 772b. A

fuel pipe 776 is connected to the fuel jet portion 775, so that the surplus fuel is supplied to the fuel jet portion 775 from the pressure regulating device 22.

[0205] In the above embodiment, the surplus fuel from the pressure regulating device 22 is supplied to the fuel jet portion 775. However, any other system may be applied to the present invention. For example, a part of fuel, which is supplied to the engine 30 but not consumed for combustion in the engine 30 and finally returned to the fuel tank 724, and which is different from the surplus fuel from the pressure regulating device 22, maybe supplied to the fuel jet portion 775. More exactly, the fuel discharged from a vapor discharge port (not shown) of the pump portion 16 may be supplied to the fuel jet portion 775, or return fuel from the engine 30 may be supplied to the fuel jet portion 775.

[0206] The filter device 740 is connected to the lower open end 772c of the fuel-transfer jet pump 771 so as to trap extraneous material included in the fuel to be sucked into the fuel-transfer jet pump 771 through the lower open end 772c. The filter device 740 is composed of a filter element 741, the valve device 60 and so on. The filter element 741 is made of non-woven film sheets (made of resinous fiber) and formed in a flat bag extending along a second bottom wall 725b of the second fuel chamber 729. The filter element 741 traps the extraneous material contained in the fuel when the fuel passes through the filter element 741.

[0207] The filter element 741 is composed of a first element 742 arranged at an upper side (on a side toward the upper wall 726 of the fuel tank 724) and a second element 744 arranged at a lower side (on a side to the second bottom wall 725b of the fuel tank 724). Each of the first and second elements 742 and 744 is formed of a thin film and overlapped in a vertical direction. An outer periphery of each element 742 and 744 is heated so that they are welded to each other to form the flat bag.

[0208] A part of the first element 742 is projected in an upward direction toward the upper wall 726 of the fuel tank 724. A left-hand end of the first element 742 is connected to the lower open end 772c of the fuel-transfer jet pump 771. The first element 742 has a slope wall portion 742a, which is upwardly inclined toward the upper wall 726 of the fuel tank 724, so that a height of the slope wall portion 742a becomes larger as a distance from the left-hand end (namely, a distance from the fuel-transfer jet pump 771) is larger. The first element 742 also has a flat wall portion 742b, which is formed at a side separated from the fuel-transfer jet pump 771 and at which the valve device 60 (which is identical to that of the first embodiment) is provided.

[0209] The second element 744 is formed in a flat cylindrical shape having a bottom end facing to the second bottom wall 725b of the fuel tank 724. A left-hand end of the second element 744 is connected to the lower open end 772c of the fuel-transfer jet pump 771. The above two elements 742 and 744 are connected to each other to form the bag-shaped filter element 741, so that the fuel passage 750 and a vapor pooling chamber 751 are formed inside of the filter element 741.

[0210] The fuel passage 750 is formed on a side to the second element 744 so as to guide the fuel, which has passed through the filter element 741 and thereby has been filtered, toward the fuel-transfer jet pump 771. The vapor pooling chamber 751 is formed at an upper portion (above the fuel passage 750) of the inside space of the filter element 741 and communicated with the fuel passage 750. The vapor pooling

chamber 751 is partly formed by the slope wall portion 742a and the flat wall portion 742b of the first element 742, like the first embodiment.

[0211] Since the valve device 60 is identical to that of the first embodiment, explanation thereof is omitted.

[0212] An operation of the fuel supply system 710 will be explained. When the electric pump 12 of the fuel supply device 711 is operated, the fuel suction force is generated. Due to the fuel suction force, the fuel in the first fuel chamber 728 flows into the electric pump 12. Then, the fuel is pressurized and discharged from the fuel supply device 711 to the pressure regulating device 22. Fuel pressure of the fuel supplied to the pressure regulating device 22 is adjusted and supplied to the engine 30. The surplus fuel discharged from the pressure regulating device 22 is supplied to the fuel jet portion 775 through the fuel pipe 776, so that the surplus fuel is emitted from the fuel jet portion 775.

[0213] When the surplus fuel is emitted from the fuel jet portion 775, fuel pressure around the fuel jet portion 775 is decreased to be lower than the fuel pressure in the filter device 740 to generate the fuel suction force. Due to the fuel suction force, the fuel pressure in the filter device 740 becomes lower than the fuel pressure outside of the filter device 740, and thereby the fuel outside of the filter device 740 passes through the filter element 741 to enter into the fuel passage 750. The vapors may be generated in the filtered fuel when the fuel passes through the filter element 741. The vapors thus generated are moved in the filter device 740 by the buoyancy upwardly toward the vapor pooling chamber 751 formed above the fuel passage 750 and pooled therein. As above, the vapors are separated from the filtered fuel having entered into the fuel passage 750.

[0214] The filtered fuel, from which the vapors are separated, goes to the lower open end 772c of the throat portion 772 along with the fuel flow formed by the fuel suction force generated at the fuel-transfer jet pump 771, as indicated by the arrows with white color in FIG. 11, and then sucked into the fuel jet passage 772a of the fuel-transfer jet pump 771. The fuel sucked into the fuel jet passage 772a is then discharged from the upper open end 772b of the throat portion 772 into the fuel transfer passage 773a together with the fuel emitted from the fuel jet portion 775. The fuel, having entered into the fuel transfer passage 773a, is discharged toward a first bottom wall 725a of the first fuel chamber 728.

[0215] According to the filter device 740 of the present embodiment, since the vapors included in the filtered fuel can be separated from the filtered fuel in the filter device 740, it is possible to suppress the flow-in of the vapors into the fuel-transfer jet pump 771 to thereby suppress a possible decrease of the pump discharge amount of the fuel-transfer jet pump 771.

[0216] As explained above, when the fuel including the vapors flows into the fuel-transfer jet pump 771, the pump discharge amount of the fuel-transfer jet pump 771 may be decreased to be lower than that of the case in which the fuel including no vapors flows into the fuel-transfer jet pump 771. In such a case, it is necessary to supply a larger amount of the surplus fuel, in order to obtain the necessary pump discharge amount. Then, it is necessary to increase a pump discharging performance of the electric pump 12, in order to obtain the larger amount of the surplus fuel. As above, the electric power consumption at the electric pump 12 should be increased, which may prevent power saving for the vehicle.

[0217] According to the filter device 740 of the present embodiment, however, since the decrease of the pump discharge amount of the fuel-transfer pump 771 can be suppressed, it is possible to obtain the necessary pump discharge amount with a smaller amount of the surplus fuel. As a result, the electric power saving can be realized for the electric pump 12. In addition, the electric pump 12 can be made smaller in size, because of the decrease of the electric power consumption.

[0218] When the vapor amount in the vapor pooling chamber 751 exceeds a predetermined amount, the vapors push up the umbrella portion 62a of the valve device 60 so that the vapors may flow out to the outside of the filter device 740. Accordingly, it is also possible to discharge the vapors in the vapor pooling chamber 751 to the outside of the filter device 740. As a result, it is possible to suppress generation of the problem that the separated vapors may flow into the fuel passage 750. It is possible, for a long term, to exert the effect for suppressing the decrease of the pump discharge amount.

Modification of Fifth Embodiment

[0219] A modification of the fifth embodiment will be explained with reference to the drawing. A fuel-transfer jet pump 871 according to the modification of the fifth embodiment is different from the fuel-transfer jet pump 771 of the fifth embodiment. The fuel supply device 711, the electric pump 12, the pressure regulating device 22, the fuel supply pipe 23 and the fuel pipe 776 according to the modification are the same to those of the fifth embodiment.

[0220] FIG. 12 is a schematic view showing a fuel supply system 810 incorporating a fuel transfer pump 870 according to the modification of the fifth embodiment. The fuel tank 724, in which the fuel supply system 810 is provided, is the saddle-type fuel tank, which is identical to the fuel tank 724 of the fifth embodiment (FIG. 10). The fuel supply system 810 is composed of the fuel supply device 711, the pressure regulating device 22, the fuel supply pipe 23, the fuel transfer pump 870 and so on. Hereinafter, the fuel transfer pump 870 will be mainly explained.

[0221] FIG. 13 is a schematic enlarged cross sectional view showing the fuel-transfer jet pump 871 of the fuel transfer pump 870. FIG. 14 is a schematic enlarged cross sectional view showing the filter device 740 of the fuel transfer pump 870.

[0222] The fuel transfer pump 870 is composed of the fuel-transfer jet pump 871, the filter device 740 and so on. The fuel-transfer jet pump 871 is composed of a throat portion 872, a fuel transfer pipe 873, a fuel inlet portion 874, a fuel jet portion 875 and so on.

[0223] The throat portion 872 is a cylindrical member made of resin material and is formed in a cylindrical shape. The throat portion 872 has a fuel jet passage 872a. The throat portion 872 is provided in the first fuel chamber 728 in such a way that a direction of the fuel jet passage 872a of the throat portion 872 is aligned with the vertical direction of the fuel tank 724. The fuel jet portion 875 is inserted into an upper open end 872b of the throat portion 872, in order to emit the surplus fuel from the pressure regulating device 22. A lower open end 872c of the throat portion 872 is opened toward the first bottom wall 725a of the first fuel chamber 728 (FIG. 12). As shown in FIG. 13, the fuel jet passage 872a has a small-diameter passage portion, at which an inner wall is elevated toward a center of the fuel jet passage 872a. The throat portion 872 has a connecting portion 872d, in which a connecting

passage 872e is formed to be communicated to the fuel jet passage 872a. The fuel transfer pipe 873 is connected to the connecting portion 872d. A left-hand end of the connecting passage 872e (that is, an end of the connecting passage 872e on a side to the throat portion 872) is opened to the fuel jet passage 872a at a portion upstream of the small-diameter passage portion.

[0224] The fuel jet portion 875 is provided in the fuel jet passage 872a at an upstream side of the small-diameter passage portion. More exactly, a fuel injection port of the fuel jet portion 875 is arranged at a position, which is at a downstream side of an opening portion at which the left-hand end of the connecting passage 872e is opened to the fuel jet passage 872a. The surplus fuel from the pressure regulating device 22 is emitted from the fuel jet portion 875 toward the lower open end 872c. The fuel pipe 776 is connected to an upper end of the fuel jet portion 875, so that the surplus fuel is supplied from the pressure regulating device 22 to the fuel jet portion 875.

[0225] In the above modification, the surplus fuel from the pressure regulating device 22 is supplied to the fuel jet portion 875. However, any other system may be applied to the present invention. For example, a part of fuel, which is supplied to the engine 30 but not consumed for combustion in the engine 30 and finally returned to the fuel tank 724, and which is different from the surplus fuel from the pressure regulating device 22, may be supplied to the fuel jet portion 875. More exactly, the fuel discharged from a vapor discharge port (not shown) of the pump portion 16 may be supplied to the fuel jet portion 875, or return fuel from the engine 30 may be supplied to the fuel jet portion 875.

[0226] The fuel inlet portion 874 is provided in the second fuel chamber, wherein the fuel inlet portion 874 is communicated to the connecting portion 872d through the fuel transfer pipe 873 forming a fuel transfer passage 873a therein (FIGS. 12 to 14). The fuel inlet portion 874 is a cylindrical member made of resin material and is formed in a cylindrical shape. The fuel inlet portion 874 has a fuel inlet passage 874a. The fuel inlet portion 874 is provided in the second fuel chamber 729 in such a way that a direction of the fuel inlet passage 874a of the fuel inlet portion 874 is aligned with the vertical direction of the fuel tank 724. The fuel transfer pipe 873 is connected to an upper open end 874b of the fuel inlet portion 874, so that the fuel inlet passage 874a is connected to the fuel transfer passage 873a. The filter device 740 is connected to a lower open end 874c of the fuel inlet portion 874, so that the fuel inlet passage 874a is communicated to the fuel passage 750 formed in the filter device 740.

[0227] The filter device 740 is connected to the lower open end 874c of the fuel inlet portion 874 so as to trap extraneous material included in the fuel to be sucked into the fuel-transfer jet pump 871 through the lower open end 874c. The filter device 740 is composed of the filter element 741, the valve device 60 and so on. The filter element 741 is made of non-woven film sheets (made of resinous fiber) and formed in the flat bag extending along the second bottom wall 725b of the second fuel chamber 729. The filter element 741 traps the extraneous material contained in the fuel when the fuel passes through the filter element 741.

[0228] The filter element 741 is composed of the first element 742 arranged at the upper side (on the side toward the upper wall 726 of the fuel tank 724) and the second element 744 arranged at the lower side (on the side to the second bottom wall 725b of the fuel tank 724). Each of the first and

second elements 742 and 744 is formed of the thin film and overlapped in the vertical direction. The outer periphery of each element 742 and 744 is heated so that they are welded to each other to form the flat bag.

[0229] The part of the first element 742 is projected in the upward direction toward the upper wall 726 of the fuel tank 724. The left-hand end of the first element 742 is connected to the lower open end 874c of the fuel inlet portion 874. The first element 742 has the slope wall portion 742a, which is upwardly inclined toward the upper wall 726 of the fuel tank 724, so that the height of the slope wall portion 742a becomes larger as the distance from the left-hand end (namely, the distance from the fuel inlet portion 874) is larger. The first element 742 also has the flat wall portion 742b, which is formed at the side separated from the fuel inlet portion 874 and at which the valve device 60 (which is identical to that of the first embodiment) is provided.

[0230] The second element 744 is formed in a flat cylindrical shape having a bottom end facing to the second bottom wall 725b of the fuel tank 724. The left-hand end of the second element 744 is connected to the lower open end 874c of the fuel inlet portion 874. The above two elements 742 and 744 are connected to each other to form the bag-shaped filter element 741, so that the fuel passage 750 and the vapor pooling chamber 751 are formed inside of the filter element 741.

[0231] The fuel passage 750 is formed on the side to the second element 744 so as to guide the fuel, which has passed through the filter element 741 and thereby has been filtered, toward the fuel inlet portion 874. The vapor pooling chamber 751 is formed at the upper portion (above the fuel passage 750) of the inside space of the filter element 741 and communicated with the fuel passage 750. The vapor pooling chamber 751 is partly formed by the slope wall portion 742a and the flat wall portion 742b of the first element 742, like the first embodiment.

[0232] Since the valve device 60 is identical to that of the first embodiment, explanation thereof is omitted.

[0233] An operation of the fuel supply system 810 will be explained. When the electric pump 12 of the fuel supply device 711 is operated, the fuel suction force is generated. Due to the fuel suction force, the fuel in the first fuel chamber 728 flows into the electric pump 12. Then, the fuel is pressurized and discharged from the fuel supply device 711 to the pressure regulating device 22. Fuel pressure of the fuel supplied to the pressure regulating device 22 is adjusted and supplied to the engine 30. The surplus fuel discharged from the pressure regulating device 22 is supplied to the fuel jet portion 875 through the fuel pipe 776, so that the surplus fuel is emitted from the fuel jet portion 875.

[0234] When the surplus fuel is emitted from the fuel jet portion 875, the fuel suction force is generated around the fuel jet portion 875. Then, the fuel is sucked from the connecting passage 872e of the connecting portion 872d, and the fuel suction force is transmitted to the fuel inlet portion 874 provided in the second fuel chamber 729 via the fuel transfer pipe 873. Due to the fuel suction force transmitted to the fuel inlet portion 874, the fuel pressure in the filter device 740 becomes lower than the fuel pressure outside of the filter device 740, and thereby the fuel outside of the filter device 740 passes through the filter element 741 to enter into the fuel passage 750. The vapors may be generated in the filtered fuel when the fuel passes through the filter element 741. The vapors thus generated are moved in the filter device 740 by the buoyancy

upwardly toward the vapor pooling chamber 751 formed above the fuel passage 750 and pooled therein. As above, the vapors are separated from the filtered fuel having entered into the fuel passage 750.

[0235] The filtered fuel, from which the vapors are separated, goes to the lower open end 874c of the fuel inlet portion 874 along with the fuel flow formed by the fuel suction force generated at the fuel-transfer jet pump 871, as indicated by the arrows with white color in FIGS. 13 and 14, and then sucked into the fuel inlet passage 874a. The fuel having entered into the fuel inlet passage 874a flows through the fuel transfer passage 873a and the connecting passage 872e, and flows into the fuel jet passage 872a. The filtered fuel sucked into the fuel jet passage 872a is discharged together with the fuel emitted from the fuel jet portion 875 toward the first bottom wall 725a of the first fuel chamber 728. As above, the fuel of the second fuel chamber 729 is filtered by the filter device 740 and discharged into the first fuel chamber 728.

[0236] According to the modification, since the throat portion 872 and the fuel jet portion 875 are provided in the first fuel chamber 728, the fuel pipe 776 for connecting the pressure regulating device 22 with the fuel jet portion 875 is also provided in the first fuel chamber 728. According to such a structure, the fuel transfer pipe 873 is only a part, which steps over the hollow portion 727 of the saddle-type fuel tank 724. A structure of the fuel supply system 810 becomes simpler.

Other Embodiments

[0237] The present invention has been explained with reference to multiple embodiments. However, the present invention should not be limited to those embodiments, but any other various modification may be made without departing from the spirit of the invention.

[0238] Any one of the fuel supply devices (11, 111, 211, 311, 411, 511) of the first to fourth embodiments may be applied to the fuel supply system 710 or 810 of the fifth embodiment or its modification.

[0239] Any type of the electric pump 12 may be applied to the fuel supply device (11, 111, 211, 311, 411, 511, or 711). For example, an electric gear pump, an electric plunger type pump, an electric trochoid pump or the like may be used.

[0240] A fuel filter may be provided between the fuel supply device (11, 111, 211, 311, 411, 511, 711) and the pressure regulating device 22, wherein the fuel filter may trap extraneous material which is smaller than the extraneous material to be trapped by the filter element (41, 141, 341a, 541, 741) of the filter device (40, 140, 240, 340, 440, 540, 740) and/or such extraneous material of wear-out brush powder produced at the electric motor. The wear-out brush powder is wear-out powder generated when the brush slides on a commutator of the electric motor.

What is claimed is:

1. A fuel pump comprising:

a pump device having a suction port and a discharge port, the pump device generating fuel suction force at the suction port and discharging pressurized fuel from the discharge port; and

a filter device connected to the suction port for filtering the fuel to be sucked into the pump device,

wherein the filter device includes;

an outer shell having a filter element of a film shape for filtering the fuel to be sucked into the pump device, the outer shell further having a fuel passage for guiding the fuel filtered by the filter element to the suction port of the

- pump device, and the outer shell further having a vapor pooling chamber formed above the fuel passage and communicated with the fuel passage so that vapors included in the fuel flowing through the fuel passage are moved from the fuel passage toward the vapor pooling chamber, and
- a valve device provided at a portion of the outer shell for communicating the vapor pooling chamber to an outside of the outer shell when an amount of the vapors pooled in the vapor pooling chamber reaches at a predetermined value.
2. The fuel pump according to the claim 1, wherein a liquid film of the fuel is formed at a surface of the filter element when the fuel entered into the filter element, and the liquid film of the fuel allows the fuel to pass through the filter element but prevents the vapors from passing through the filter element.
 3. The fuel pump according to the claim 1, wherein the outer shell has a slope wall portion at an upper side thereof, and the slope wall portion is upwardly inclined such that a height of the slope wall portion becomes larger as the slope wall portion is closer to the valve device.
 4. The fuel pump according to the claim 3, wherein the slope wall portion is formed by the filter element.
 5. The fuel pump according to the claim 3, wherein the slope wall portion is upwardly inclined such that the height of the slope wall portion becomes larger as the slope wall portion is further away from the suction port.
 6. The fuel pump according to the claim 3, wherein the valve device is provided at a highest position of the outer shell.
 7. The fuel pump according to the claim 1, wherein the valve device comprises:
 - a valve seat member having a seat portion formed at an outer surface of the filter device and a communication hole formed at an inner area of the seat portion for communicating the vapor pooling chamber to the outside of the filter device; and
 - a valve body member disposed at the outer surface of the filter device, the valve body member being pushed by the vapors in the vapor pooling chamber and thereby being separated from the seat portion so that the valve body member allows the vapors to flow from the vapor pooling chamber to the outside of the filter device, while the valve body member being seated on the seat portion when the amount of the vapors in the vapor pooling chamber is decreased so that the valve body member prevents the fuel from flowing from the outside of the filter device into the inside of the filter device.
 8. The fuel pump according to the claim 1, wherein the fuel passage is composed of a first fuel passage and a second fuel passage, the second fuel passage being formed between the first fuel passage and the suction port of the pump device so that the first fuel passage is communicated to the suction port, the outer shell is composed of the filter element and a tank wall member of a tank portion, the filter element forming therein the first fuel passage, the tank portion forming therein the second fuel passage and the vapor pooling chamber above the second fuel passage, the filter element is provided at a lower end of the tank portion, so that the first fuel passage is communicated to the second fuel passage, and the valve device is provided at a portion of the tank portion, at which the vapor pooling chamber is formed.
 9. The fuel pump according to the claim 8, wherein the valve device comprises:
 - a valve seat member provided at the tank portion, the valve seat member having a seat portion formed at an outer surface of the filter device and a communication hole formed at an inner area of the seat portion for communicating the vapor pooling chamber to the outside of the filter device; and
 - a valve body member disposed at the outer surface of the filter device, the valve body member being pushed by the vapors in the vapor pooling chamber and thereby being separated from the seat portion so that the valve body member allows the vapors to flow from the vapor pooling chamber to the outside of the filter device, while the valve body member being seated on the seat portion when the amount of the vapors in the vapor pooling chamber is decreased so that the valve body member prevents the fuel from flowing from the outside of the filter device into the inside of the filter device.
 10. The fuel pump according to the claim 8, further comprising:
 - an auxiliary jet pump provided between the first fuel passage and the second fuel passage, wherein the auxiliary jet pump includes;
 - a throat portion forming a fuel jet passage, one end of which is opened to the first fuel passage and the other end of which is opened to the second fuel passage, and
 - a fuel jet portion provided in the fuel jet passage for emitting fuel toward the other end of the fuel jet passage opened to the second fuel passage.
 11. The fuel pump according to the claim 1, further comprising:
 - a filter frame provided in the filter device for supporting an inner surface of the outer shell.
 12. The fuel pump according to the claim 1, further comprising:
 - the pump device is composed of an electric pump for generating the fuel suction force in order to draw the fuel from the suction port, the electric pump pressurizes the fuel and discharges such pressurized fuel from the discharge port.
 13. The fuel pump according to the claim 1, further comprising:
 - a jet pump includes;
 - a throat portion forming a fuel jet passage having an inlet open end and an outlet open end; and
 - a fuel jet portion provided in the fuel jet passage for emitting fuel toward the outlet open end, so that fuel suction force is generated at the inlet open end, wherein the fuel sucked into the fuel jet passage from the inlet open end is discharged from the outlet open end together with the fuel emitted from the fuel jet portion.
 14. A fuel supply system for a vehicle comprising:
 - an electric pump device arranged in a fuel tank for supplying fuel to an engine of the vehicle; and
 - a filter device connected to a suction port of the electric pump device for filtering fuel to be sucked into the electric pump device, wherein the filter device includes;
 - a bag-shaped filter element forming therein a fuel passage into which the fuel in the fuel tank enters by passing through the filter element, the filter element further

forming therein a vapor pooling chamber above the fuel passage so that vapors separated from the fuel are moved to the vapor pooling chamber; and

a valve device provided at a portion of the bag-shaped filter element which is close to the vapor pooling chamber, the valve device being opened when an amount of vapors exceeds a predetermined value so as to communicate the vapor pooling chamber to an outside of the filter device to thereby discharge the vapors to the outside thereof.

15. A fuel supply system for a vehicle comprising:

- an electric pump device arranged in a fuel tank for supplying fuel to an engine of the vehicle;
- a pressure regulating device for regulating fuel pressure of the fuel to be supplied to the engine; and
- a filter device connected to a suction port of the electric pump device for filtering fuel to be sucked into the electric pump device,

wherein the filter device includes;

- a bag-shaped filter element forming therein a first fuel passage into which the fuel in the fuel tank enters by passing through the filter element;
- a tank portion forming therein a second fuel passage, the tank portion having a coupling portion connected to the suction port of the electric pump device so that the fuel from the second fuel passage is supplied to the electric pump device, the tank portion further having a vapor pooling chamber above the second fuel passage so that vapors separated from the fuel are moved to the vapor pooling chamber;
- a jet pump provided between the filter element and the tank portion, the jet pump having a throat portion forming a fuel jet passage having an inlet open end and an outlet open end, the jet pump further having a fuel jet portion provided in the fuel jet passage for emitting surplus fuel from the pressure regulating device toward the outlet open end so that fuel suction force is generated at the inlet open end, and the fuel sucked into the fuel jet passage from the inlet open end being discharged from the outlet open end together with the surplus fuel emitted from the fuel jet portion; and
- a valve device provided at a portion of the tank portion which is close to the vapor pooling chamber, the valve device being opened when an amount of vapors exceeds

- a predetermined value so as to communicate the vapor pooling chamber to an outside of the filter device to thereby discharge the vapors to the outside thereof.

16. A fuel supply system for a vehicle comprising:

- an electric pump device arranged in a first tank portion of a saddle-type fuel tank for supplying fuel to an engine of the vehicle;
- a pressure regulating device for regulating fuel pressure of the fuel to be supplied to the engine;
- a jet pump arranged in a second tank portion of the fuel tank;
- a filter device also arranged in the second tank portion and connected to the jet pump for filtering fuel in the second tank portion;
- a fuel transfer pipe connected at one end to the jet pump and communicated at the other end to the first tank portion, wherein the jet pump includes;
- a throat portion forming a fuel jet passage having an inlet open end connected to the filter device and an outlet open end connected to the fuel transfer pipe; and
- a fuel jet portion provided in the fuel jet passage for emitting surplus fuel from the pressure regulating device toward the outlet open end so that fuel suction force is generated at the inlet open end, the fuel sucked into the fuel jet passage from the filter device being discharged from the outlet open end together with the surplus fuel emitted from the fuel jet portion, and the fuel discharged from the jet pump being transferred to the first tank portion via the fuel transfer pipe, and

wherein the filter device includes;

- a bag-shaped filter element forming therein a fuel passage into which the fuel from the second fuel tank enters through the filter element, the filter element further forming therein a vapor pooling chamber above the fuel passage; and
- a valve device provided at a portion of the bag-shaped filter element which is close to the vapor pooling chamber, the valve device being opened when an amount of vapors exceeds a predetermined value so as to communicate the vapor pooling chamber to an outside of the filter device to thereby discharge the vapors to the outside thereof.

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