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DESCRIPTION

Description

Background Art

[0001] The present invention relates to a hydrogen refueling system, for example a hydrogen refueling station (HRS).

Description of the Related Art

[0002] In hydrogen refueling stations (HRS), which purpose is to refuel Fuel Cell Vehicles (FCV) (512, 518) with hydrogen, a dispenser (505) is typically equipped with one hose (510), sometimes two hoses (typically one for refueling at 35 MPa and one for refueling at 70 MPa) as shown figure 5A and 5B. Also, in order to comply with current refueling protocols and achieve fast refueling of FCV (typical target is 5 kg within 3 minutes or according to the SAE J 2601), some high pressure (HP) buffer bank(s) (504) are installed upstream the dispenser (505) to provide high H₂ flow rate during refueling. The HP buffer bank(s) (4) need to be filled at a minimum pressure before to start refueling in order to follow the pressure ramp specified by the refueling protocol and to achieve successful refueling.

[0003] HRS are typically equipped only with one dispenser (505). However, some peak load hours exist where several FCVs (512, 518) will come within a short period of time.

[0004] When one FCV (518) is queuing, the typical sequence is as follows.

[0005] Upon termination of refueling of the first FCV (512), customer or operator has to disconnect the nozzle (511) and place it back on the dispenser (505).

[0006] First FCV (512) customer has to proceed to payment.

[0007] First FCV(512) is moved out of the dispenser (505) area.

[0008] Second FCV (518) can move in front of the dispenser (505).

[0009] Second FCV (518) customer initiates payment by card (if applicable).

[0010] Customer or operator connects the refueling nozzle (511) to the second FCV (518).

[0011] If HP buffers (504) have not yet been refilled to the target pressure, customer has to wait for the end of HP buffers (504) refilling.

[0012] Customer or operator can press the start button. After pressing the start button, it makes to launch the connection leak test and to begin refueling.

[0013] Typically, this complete sequence between the end of H₂ transfer to the first FCV (512) to the beginning of H₂ transfer to the second FCV (518) can take 3 minutes or more.

[0014] Also, HP buffer(s) (504) refilling target pressure is a fixed value predefined to achieve successful refueling of a FCV (512, 518) having a tank (513, 519) almost empty. As a consequence, a customer may wait for the HP buffer(s) (504) to be refilled up to target pressure, even though his tank has significant remaining pressure, and successful refueling could be achieved with lower target pressure(s). In addition, precooling power may be sized by considering some interval between two FCV(512, 518) refueling and some timer may need to be elapsed before authorizing refueling of the next FCV (518). As a consequence, a customer may wait for the re-accumulation of enough cold to perform refueling of a tank almost empty even though his tank (519) has significant remaining pressure, and successful refueling could be achieved with shorter delay.

[0015] Document D1, JP2015190596 A1, discloses that the determining unit determines the number of vehicles which is capable of refueling with H₂ within a prescribed time based on the acquired pressure in the accumulator, and determines the waiting time of the vehicle for refueling based on the filling time required for filling the accumulator with hydrogen using the hydrogen stored in the accumulator and the sum of the number of vehicles that are refueling H₂ by the dispenser and the number of vehicles that are waiting for refueling H₂ by the dispenser. And the paragraph [0043] in this document discloses that since the remaining pressure in the tank of the vehicles that are waiting for refueling H₂ is unknown, the specified period of time (for example 5 minutes) for refueling process is required.

[0016] Document D2, US6901302 B1, discloses some network communication with a fleet of vehicles circulating in view of anticipating the load of HRS (i.e. producing the appropriate quantity of H₂ to refuel the vehicles). And this document discloses the transmission of remaining quantity or remaining pressure in the vehicle to the station (HRS) for controlling the station load in view of filling time.

[0017] US 8 708 005 B2 discloses a gas filling system.

SUMMARY OF THE INVENTION

[0018] In the prior art system of figures 3 to 4, since the next vehicle can move to the dispenser

and connect refueling hose only after previous vehicle has gone away, some operations other than actual H₂ transfer to vehicle tank, such as payment completion process, car moving time, initiation payment process, etc., must be counted as waiting time for the next vehicle.

[0019] The document 1 only disclose about the improvement the user's convenience by calculating and displaying the waiting time of the vehicle based on the states such as the number of vehicles being filled, the number of waiting vehicles, the pressure in the accumulator, and H₂ filling time to the accumulator.

[0020] The document 2 only disclose that configured to receive amount of H₂ in the tank from a vehicle that is traveling to HRS, to compare with the amount of hydrogen stock in HRS and to judge the excess/deficiency level, to operate the hydrogen generator according to the excess/deficiency level and to keep the hydrogen stock.

[0021] Therefore, the prior art system of figures 3 to 4, D1 and D2 don't reduce the waiting time of the next vehicle in one dispenser.

[0022] The purpose of this patent is to describe solutions to minimize customer waiting time with keeping only one dispenser (5) at HRS, or having pieces of equipment shared by two dispensers (5). This invention can provide a hydrogen refueling system capable to reduce a waiting time for refueling H₂ to the vehicle.

[0023] As first invention, a hydrogen refueling system in accordance with independent claim 1 is provided. The system includes as main design characteristic to have a H₂ dispensing system (dispenser) with two H₂refueling hoses which has only one H₂ flow control valve and/or only one H₂ cooling heat exchanger and/or only one H₂ flow metering system.

[0024] As first invention, the hydrogen refueling system including:

at least one H₂supply source(1) that stores H₂ which has a first pressure;

compressor(2) that is able to increase H₂ pressure and which can transfer H₂from one container(e.g. MP buffer(3)) or H₂ supply source(1) to another(e.g. MP buffer(3), HP buffer bank(s)(4a, 4b, 4c));

one or several HP buffer bank(s)(4a, 4b, 4c) that store H₂ under various pressures or same pressure (various predetermined pressures or same predetermined pressure), generally higher than pressure of the H₂ supply source(1);

optionally, one (or more) MP buffer (3(3a, 3b, 3c)) that store H₂ under a pressure (a predetermined pressure), generally higher than pressure of the H₂supply source (1) and generally lower than the pressure of HP buffer bank(s)(4a, 4b, 4c);

at least one dispenser (5), which can transfer and discharge H₂ from at least one container

(e.g. H₂ supply source(1), MP buffer(3), HP buffer bank(s)(4a, 4b, 4c)) and/ or from compressor (2) discharge into the tank (13, 19) of a vehicle;

optionally, one heat exchanger (8), which can cool down H₂ before being transferred to the tank(13, 19) of a vehicle and which is fed with a cooling fluid;

first controller(30) that controls the compressor(2) and one or more valve(s)(e.g. 40, 41a, 41b, 41a, 43a, 44a) placed on pipe(s)(i.e. 50, 52, 53, 54a, 55a, 56a) in such a way that, when the station is idle (i.e. no vehicle is refueled or is waiting), depending on pre-determined operation steps, H₂ is transferred from one container (1, 3(3a, 3b, 3c), 4a, 4b, 4c) to another, up to pre-determined target pressure value(s) (P_{set}) in recipient container(s) (3(3a, 3b, 3c), 4a, 4b, 4c), for example, in the case there is one MP buffer (3), in one operation step controlled by first controller, H₂ is transferred from H₂ supply source(1) to MP buffer (3) through the compressor (2) until the pressure in MP buffer (3) reaches a pre-determined target pressure which is higher than the pressure of the H₂ supply source(1), and in other operation steps controlled by first controller (30), H₂ is transferred from MP buffer (3) to one HP buffer bank(s) (4a, 4b, 4c) through the compressor (2) until the pressure in HP buffer banks(s) (4a, 4b, 4c) reaches a pre-determined target pressure which is higher than the pressure in MP buffer (3); data processor (35) that, when one vehicle (12,18) is connected to be re-fueled, reads the residual pressure in the tank (13, 19) of the vehicle (12,18), using nozzle (11, 17) IR communication device or pressure sensor (14, 20) and, depending on the residual pressure in vehicle tank (13, 19), depending on pressure in the containers (1, 3(3a, 3b, 3c), 4a, 4b, 4c) and depending on ambient temperature, calculates target pressure value(s) (TP) in one or several containers (1, 3(3a, 3b, 3c), 4a, 4b, 4c) optimized to be sufficient to achieve complete refueling of connected vehicle (12,18).

[0025] In case one heat exchanger (8) is present, data processor (35) may as well calculate, depending on the residual pressure in vehicle tank, depending on quantity of H₂ refueled in previous vehicle(s) and depending on ambient temperature, the sufficient conditions to achieve refueling of connected vehicle according to low H₂ temperature refueling protocol, such as minimum time interval with previous vehicle or maximum temperature of the heat exchanger (8).

[0026] The hydrogen refueling system further includes:

second controller(40) that, when one vehicle (12,18) is connected to be re-fueled, may use the conditions calculated by data processor (35) to decide and execute an optimized sequence that controls the compressor (2) and valves to reach target pressure value(s) (TP) in the container(s) (3(3a, 3b, 3c), 4a, 4b, 4c) calculated by the data processor (35).

[0027] In the hydrogen refueling system,

the optimized sequence is decided in such a way that the time for being able to reach the conditions calculated by the data processor (35) after connecting a refueling nozzle(11, 17) to

the vehicle is a minimum time. This minimum time is zero when sufficient conditions to achieve complete refueling of connected vehicle are already met when the refueling nozzle(11, 17) is connected to the vehicle.

[0028] The hydrogen refueling system further includes:

third controller(45) that, when the conditions calculated by data processor (35) are met, controls the compressor (2) and valve(s)(e.g. 40, 41a, 41b, 41a, 42b, 43a, 43b, 44a, 44b, 6, 9, 15) according to a pre-determined strategy and filling protocol, in such a way that H₂ is transferred from at least one container (1, 3(3a, 3b, 3c), 4a, 4b, 4c) to the tank of the vehicle.

[0029] The first controller(30)and second controller (40) may control one or more valve(s)(e.g. 40, 41a, 41b, 41a, 43a, 44a) which is(are) placed on pipe(s)(e.g. 50, 52, 53, 54a, 55a, 56a) in order to transfer H₂ from one container (1, 3, 4a, 4b, 4c) to another, either directly or through the compressor(2).

[0030] Target pressure value(s)(TP) in the container(s) (3(3a, 3b, 3c), 4a, 4b, 4c) calculated by the data processor (35) may be lower than the pre-determined target pressure value(s) (P_{set}) in recipient container(s) (3, 4a, 4b, 4c) used by first controller (30). In addition, target pressure values(TP) in HP buffer banks(4a, 4b, 4c) calculated by the data processor (35) may be the same value for all HP buffer banks or different values.

[0031] Based on a container order(e.g. HP buffer bank (4a), then HP buffer bank (4b), then HP buffer bank (4c)) that may be calculated depending on remaining pressure in the containers (1, 3, 4a, 4b, 4c), the third controller(45) may control valves (e.g. 40, 41a, 42a, 42b, 43a, 43b, 44a, 44b, 6, 9, 15) to connect one of the containers (1, 3, 4a, 4b, 4c) to the FCV tank(13, 19) and then to refuel H₂ into the FCV tank by balancing pressures between the connected container and the FCV tank (13, 19), and then, after disconnecting the used container, to connect another of the containers (1, 3, 4a, 4b, 4c) to the FCV tank (13, 19) and then to refuel H₂ into the FCV tank (13, 19) by balancing pressures between the connected container and the FCV tank (13, 19). And then, the sequence may be repeated with other containers (1, 3, 4a, 4b, 4c), depending on a pre-defined strategy. For example, the containers order may be calculated to connect first the container having the lowest remaining pressure, and then follow the order of increasing remaining pressure in the containers used to refuel H₂.

[0032] When refueling H₂into the FCV tank (13, 19) by switching between containers, balancing pressures between the connected container and the FCV tank (13, 19) may be partial. Changing to the next container may be made when there is still a large pressure difference between the connected container (1, 3, 4a, 4b, 4c) and the FCV tank (13, 19), for example when the refueling flow rate required by fueling protocol cannot be maintained, due to the flow restrictions between the connected container (1, 3, 4a, 4b, 4c) and the FCV tank (13, 19).

[0033] In case that there are two or more MP buffers (3(3a 3b 3c)), the pre-determined target

pressure value may be the same value for all MP buffers or different values.

[0034] In case that there are two or more HP buffer banks(4a, 4b, 4c), the pre-determined target pressure value may be the same value for all HP banks or different values.

[0035] As the first invention,

the at least one of dispenser(5) may include,

a control valve(6) that is placed on a main line (57) through which is sent the H₂ from the containers (1, 3, 4a, 4b, 4c);

a metering device(7) that is placed downstream the control valve (6) on the main line (57);

a heat exchanger(8) that is placed downstream the metering device(7) on the main line (57) and cools or warms the H₂ through the main line (57);

first and second branch lines (57a, 57b) that are branched from the main line (57) downstream the heat exchanger(8);

first on-off valve(9) that is placed on the first branch line (57a);

second on-off valve(15) that is placed on the second branch line (57b);

first hose(10) that has a first refueling nozzle(11) at its one end part and is connected the first branch line (57a) at its another end part; and

second hose(16) that has a second refueling nozzle(17) at its one end part and is connected the second branch line (57b) at its another end part.

[0036] In the first invention,

the at least one of dispenser(5) may include,

first and second interface (21, 22);

the first interface (21) may include first payment interface, first ticket system, and first metering display;

the second interface(22) may include second payment interface, second ticket system, and second metering display.

[0037] In the first invention,

the third controller(45) may control first refueling process which is configured to refuel the

H₂ through the first hose(10) from the first refueling nozzle(11) into first FCV tank(13) of first vehicle(12), and / or

the third controller(45) may control second refueling process which is configured to refuel the H₂ through the second hose(16) from the second refueling nozzle(17) into second FCV tank(19) of second vehicle(18);

in case of a first refueling process,

the data processor(35) may acquire first residual pressure of the first FCV tank(13) which is connected with the first refueling nozzle(11) and may calculate sufficient conditions to achieve complete refueling of first vehicle (12);

second controller(40) may use the conditions calculated by data processor (35) to decide and execute an optimized sequence that controls the compressor (2) and valves to reach within a minimum time the target pressure value(s)(TP) in the container(s) (1, 3, 4a, 4b, 4c) calculated by the data processor (35);

when the conditions calculated by data processor (35) are met and provided that H₂ transfer with second nozzle (17) is already finished, third controller (45) may proceed with refueling of first vehicle (12);

in case of the second refueling process,

the data processor (35) may acquire second residual pressure of the second FCV tank(19) which is connected with the second refueling nozzle(17) and calculate sufficient conditions to achieve complete refueling of second vehicle (18);

second controller(40) may use the conditions calculated by data processor (35) to decide and execute an optimized sequence that controls the compressor (2) and valves to reach within a minimum time the target pressure value(s) (TP) in the container(s) (1, 3, 4a, 4b, 4c) calculated by the data processor (35);

when H₂ transfer with first nozzle (11) is finished, transfer of H₂ with first nozzle (11) is finished and when the conditions calculated by data processor (35) are met, third controller (45) may proceed with refueling of second vehicle (18).

[0038] In the first invention, the first residual pressure may be measured by first pressure sensor(14) which is placed downstream the first on-off valve(9) on the first branch line (57a), and/or

the second residual pressure may be measured by second pressure sensor(20) which is placed downstream the second on-off valve(15) on the second branch line (57b).

[0039] In the first invention, the third controller(45) may control temperature and/or flow rate of cooling fluid which is sent to the heat exchanger(8) to control temperature of the H₂ which is refueled into the FCV tank.

[0040] In the first invention, the second controller(40) may calculate an expected waiting time which is period for being able to start refueling process from after completing payment initiation or after connecting the nozzle to the first or second FCV tank and output the expected waiting time to output device; and/or

the second controller(40) may calculate an expected complete time which is period for completing refueling process from after completing payment initiation or after connecting the nozzle to the first or second FCV tank and output the expected complete time to output device.

[0041] In the first invention, the dispenser(5) includes two H₂ refueling hoses (10, 16), only one H₂ flow control valve (6) and/or only one H₂ cooling heat exchanger (8) and/or only one H₂ flow metering system (7).

[0042] Second invention is a method for operating refueling process in accordance with independent claim 4. The refueling process is under the condition that two vehicles can be connected at the same time to the H₂ dispensing system and refueling of the second vehicle is started as soon as transfer of H₂ to the first vehicle is finished and conditions calculated by the data processor (35) are met.

[0043] As second invention, the method for performing first refueling process which refuels H₂ to first FCV tank(13) of first vehicle(12) and second refueling process which refuels H₂ to second FCV tank(19) of second vehicle(18), the first and second vehicles(12,18) is stopped in refueling range of only one dispenser(5), including:

in case of a first refueling process,

acquiring first residual pressure of the first FCV tank(13) which is connected with the first refueling nozzle(11) and calculating sufficient conditions to achieve complete refueling of first vehicle (12);

using the conditions calculated by data processor (35) to decide and execute an optimized sequence that controls the compressor (2) and valves to reach within a minimum time the target pressure value(s)(TP) in the container(s) (1, 3, 4a, 4b, 4c) calculated by the data processor (35);

proceeding with refueling of first vehicle (12) when the conditions calculated by data processor (35) are met and provided that H₂ transfer with second nozzle (17) is already finished;

in case of the second refueling process,

acquiring second residual pressure of the second FCV tank(19) which is connected with the second refueling nozzle(17) and calculating sufficient conditions to achieve complete refueling of second vehicle (18);

using the conditions calculated by data processor (35) to decide and execute an optimized sequence that controls the compressor (2) and valves to reach within a minimum time the

target pressure value(s) (TP) in the container(s) (1, 3, 4a, 4b, 4c) calculated by the data processor (35);

proceeding with refueling of second vehicle (18) when transfer of H₂ with first nozzle (11) is finished and when the conditions calculated by data processor (35) are met.

Brief Description of Drawings

[0044]

[fig.1] Fig. 1 illustrates an explanatory diagram showing a hydrogen refilling system according to Embodiment 1.

[fig.2] Fig. 2 illustrates an explanatory diagram showing lay-out of a hydrogen refilling system.

[fig.3] Fig. 3 illustrates an explanatory diagram showing another lay-out of a hydrogen refilling system.

[fig.4] Fig. 4 illustrates an explanatory flowchart showing a dispenser according to Embodiment 1.

[fig.5A] Fig. 5A illustrates an explanatory diagram showing prior art process scheme of a hydrogen refilling system.

[fig.5B] Fig. 5B illustrates an explanatory diagram showing prior art lay-out of a dispenser.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0045] Several embodiments of the present invention will be explained below. The embodiments explained below are to explain one example of the present invention. The present invention is not limited to the following embodiments at all and includes various types of modifications carried out within the scope of the appended claims.

(Embodiment 1)

[0046] The hydrogen refueling system 1 of the first embodiment is explained by referring figures 1 to 4. The hydrogen refueling system 100 includes a H₂ supply source 1, a compressor 2, MP buffers 3a, 3b, 3c, HP buffer banks 4a, 4b, 4c and a dispenser 5. The following is described in detail.

[0047] H₂ supply source 1 stores H₂ which has a first pressure.

[0048] The compressor 2 increases H₂ pressure and transfer H₂ from H₂ supply source 1 to MP buffers(3a, 3b, 3c), from H₂ supply source 1 to HP buffer banks(4a, 4b, 4c), or from MP buffers(3a, 3b, 3c) to HP buffer banks(4a, 4b, 4c) and/or the dispenser 5.

[0049] MP buffers (3a, 3b, 3c) store H₂ under a pressure which is higher than pressure of the H₂ supply source 1 and lower than the pressure of HP buffer banks(4a, 4b, 4c).

[0050] HP buffer banks(4a, 4b, 4c) store H₂ under various pressures which is higher than pressures of the H₂ supply source 1 and MP buffers(3a, 3b, 3c).

[0051] The dispenser 5 transfers H₂ from at least one container (e.g. H₂ supply source 1, MP buffers (3a, 3b, 3c), HP buffer banks(4a, 4b, 4c)) and/or from compressor discharge to the tank (13, 19) of a vehicle(12, 18).

[0052] The dispenser 5 includes only two H₂ refueling hoses 10, 16, only one H₂ flow control valve 6, only one H₂ cooling heat exchanger 8, and only one H₂ flow metering device 7.

[0053] The heat exchanger 8 cools down H₂ before being transferred to the tank (13, 19) of a vehicle (12, 18). The heat exchanger 8 is fed with a cooling fluid to cool down H₂. The heat exchanger 8 is placed downstream the metering device 7 on the main line 57.

[0054] The control valve(6) is placed on a main line 57 through which is sent the H₂ from the containers (1, 3a, 3b, 3c, 4a, 4b, 4c).

[0055] The metering device 7 is placed downstream the control valve 6 on the main line 57.

[0056] H₂ flow control valve 6 is controlled based on the filling protocol (e.g. by controlling pressure at the outlet of dispenser (5) to follow a predefined pressure ramp).

[0057] First and second branch lines 57a, 57b are branched from the main line 57 downstream the heat exchanger 8.

[0058] First on-off valve 9 is placed on the first branch line 57a. Second on-off valve 15 is placed on the second branch line (57b).

[0059] First hose 10 has a first refueling nozzle 11 at its one end part and is connected the first branch line 57a at its another end part. Second hose 16 has a second refueling nozzle 17 at its one end part and is connected the second branch line 57b at its another end part.

[0060] Dispenser 5 includes first and second interface 21, 22. The first interface 21 includes first payment interface, first ticket system, and first metering display. The second interface 22 includes second payment interface, second ticket system, and second metering display.

[0061] First controller 30 control the compressor 2 and one or more valve(s)(40, 41a, 41b, 41a, 43a, 44a) placed on pipes (50, 52, 53, 54a, 55a, 56a) in such a way that, when the station is idle (i.e. no vehicle is refueled or is waiting), depending on pre-determined operation steps, H₂ is transferred from one container (1, 3a, 3b, 3c, 4a, 4b, 4c) to another, up to pre-determined target pressure value(s) (P_{set}) in recipient containers (3a, 3b, 3c, 4a, 4b, 4c), for example, in the case there is one MP buffer , in one operation step controlled by first controller 30, H₂ is transferred from H₂ supply source 1 to MP buffers (3 (3a, 3b, 3c)) through the compressor 2 until the pressure in MP buffer 3 reaches a pre-determined target pressure which is higher than the pressure of the H₂ supply source 1, and in other operation steps controlled by first controller 30, H₂ is transferred from MP buffers (3 (3a, 3b, 3c)) to one HP buffer banks (4a, 4b, 4c) through the compressor 2 until the pressure in HP buffer banks (4a, 4b, 4c) reaches a pre-determined target pressure which is higher than the pressure in MP buffers (3(3a, 3b, 3c)).

[0062] The data processor 35 reads the residual pressure in the tank (13, 19) of the vehicle (12,18) when one vehicle (12,18) is connected to be re-fueled. The residual pressure is provided or measured by using nozzle IR communication device or pressure sensor (14, 20).

[0063] Depending on residual pressure in vehicle tank(13, 19), depending on pressure in the containers (1, 3a, 3b, 3c, 4a, 4b, 4c), and depending on ambient temperature, the data processor 35 calculates target pressure value(s) (TP) in one or several container(s) (1, 3a, 3b, 3c, 4a, 4b, 4c) optimized to be sufficient to achieve complete refueling of connected vehicle (12,18).

[0064] The heat exchanger 8 being present, data processor 35 may as well calculate depending on residual pressure in vehicle tank (13, 19), depending on quantity of H₂ refueled in previous vehicle and depending on ambient temperature, sufficient conditions to achieve refueling of connected vehicle according to low H₂temperature refueling protocol, such as minimum time interval with previous vehicle or maximum temperature of the heat exchanger (8).

[0065] The second controller 40, when one vehicle (12,18) is connected to be re-fueled, uses the conditions calculated by the data processor 35 to decide and execute an optimized sequence that controls the compressor 2 and valves to reach target pressure value(s) (TP) in the container(s) (1, 3a, 3b, 3c, 4a, 4b, 4c) calculated by the data processor 35.

[0066] The optimized sequence is decided in such a way that the time for being able to reach the conditions calculated by the data processor 35 after connecting a refueling nozzle (11, 17) to the vehicle is a minimum time.

[0067] This minimum time is zero when sufficient conditions to achieve complete refueling of connected vehicle are already met when the refueling nozzle (11, 17) is connected to the vehicle.

[0068] Third controller 45 , when the conditions calculated by the data processor 35 are met, controls the compressor 2 and valves (40, 41a, 41b, 41a, 42b, 43a, 43b, 44a, 44b, 6, 9, 15) according to a pre-determined strategy and filling protocol, in such a way that H₂ is transferred from at least one container (1, 3a, 3b, 3c, 4a, 4b, 4c) to the tank (13, 19) of the vehicle (12, 18).

[0069] The first controller 30 and the second controller 40 may control one or more valves (40, 41a, 41b, 41a, 43a, 44a) which are placed on pipes(50, 52, 53, 54a, 55a, 56a) in order to transfer H₂ from one container (1, 3, 4a, 4b, 4c) to another, either directly or through the compressor 2.

[0070] Target pressure values(TP) in the containers (3a, 3b, 3c, 4a, 4b, 4c) calculated by the data processor 35 may be lower than the pre-determined target pressure value (P_{set}) in each recipient container (3a, 3b, 3c, 4a, 4b, 4c) used by first controller 30. In addition, target pressure values (TP) in HP buffer banks(4a, 4b, 4c) calculated by the data processor 35 may be the same value for all HP buffer banks or different values .

[0071] Based on a container order(HP buffer bank 4a, then HP buffer bank 4b, then HP buffer bank 4c) that may be calculated depending on remaining pressure in the containers (3a, 3b, 3c, 4a, 4b, 4c), the third controller 45 may control valves (42b, 43b, 44b, 6, 9, 15) to connect one of the containers (4a, 4b, 4c) to the FCV tank(13, 19) and then to refuel H₂ into the FCV tank by balancing pressures between the connected container and the FCV tank (13, 19), and then, after disconnecting the used container, to connect another of the containers (4a, 4b, 4c) to the FCV tank (13, 19) and then to refuel H₂ into the FCV tank (13, 19) by balancing pressures between the connected container and the FCV tank (13, 19). And then, the sequence may be repeated with other containers (4a, 4b, 4c), depending on a pre-defined strategy. For example, the containers order may be calculated to connect first the container having the lowest remaining pressure, and then follow the order of increasing remaining pressure in the containers used to refuel H₂.

[0072] When refueling H₂ into the FCV tank (13, 19) by switching between containers, balancing pressures between the connected container and the FCV tank (13, 19) may be partial. Changing to the next container may be made when there is still a large pressure difference between the connected container (4a, 4b, 4c) and the FCV tank (13, 19), for example when the refueling flow rate required by fueling protocol cannot be maintained, due to the flow restrictions between the connected container (4a, 4b, 4c) and the FCV tank (13, 19).

[0073] The third controller 45 may control first refueling process which is configured to refuel

the H₂ through the first hose 10 from the first refueling nozzle 11 into first FCV tank 13 of first vehicle 12. The third controller 45 may control second refueling process which is configured to refuel the H₂ through the second hose 16 from the second refueling nozzle 17 into second FCV tank 19 of second vehicle 18.

[0074] In case of a first refueling process, the data processor 35 may acquire first residual pressure of the first FCV tank 13 which is connected with the first refueling nozzle 11 and may calculate sufficient conditions to achieve complete refueling of first vehicle 12. The second controller 40 may use the conditions calculated by data processor 35 to decide and execute an optimized sequence that controls the compressor 2 and valves to reach within a minimum time the target pressure value(s) (TP) in the container(s) (3a, 3b, 3c, 4a, 4b, 4c) calculated by the data processor 35. when the conditions calculated by data processor 35 are met, third controller 45 may proceed with refueling of first vehicle 12.

[0075] In case of the second refueling process, the data processor 35 may acquire second residual pressure of the second FCV tank 19 which is connected with the second refueling nozzle 17 and calculate sufficient conditions to achieve complete refueling of second vehicle 18. The second controller 40 may use the conditions calculated by data processor 35 to decide and execute an optimized sequence that controls the compressor 2 and valves to reach within a minimum time the target pressure value(s) (TP) in the container(s) (3a, 3b, 3c, 4a, 4b, 4c) calculated by the data processor 35. When transfer of H₂ with first nozzle (11) is finished and when the conditions calculated by data processor 35 are met, third controller 45 may proceed with refueling of second vehicle 18.

[0076] The first residual pressure may be measured by first pressure sensor 14 which is placed downstream the first on-off valve 9 on the first branch line 57a. The second residual pressure may be measured by second pressure sensor 20 which is placed downstream the second on-off valve 15 on the second branch line 57b.

[0077] The third controller 45 may control temperature and/or flow rate of cooling fluid which is sent to the heat exchanger 8 to control temperature of the H₂ which is refueled into the FCV tank.

[0078] The second controller 40 may calculate an expected waiting time which is period for being able to start refueling process from after completing payment initiation or after connecting the nozzle to the first or second FCV tank and output the expected waiting time to output device. The second controller 40 may calculate an expected complete time which is period for completing refueling process from after completing payment initiation or after connecting the nozzle to the first or second FCV tank and output the expected complete time to output device. The output device is for example, display, speaker, another computer, server, memory.

(method for embodiment 1)

[0079] The method for performing first refueling process which refuels H₂ to first FCV tank 13 of first vehicle 12 and second refueling process which refuels H₂ to second FCV tank 19 of second vehicle 18, the first and second vehicles (12,18) being stopped in refueling range of only one dispenser 5, includes the following steps;

in case of a first refueling process, step of acquiring first residual pressure of the first FCV tank 13 which is connected with the first refueling nozzle 11 and calculating sufficient conditions to achieve complete refueling of first vehicle 12, step of using the conditions calculated by data processor (35) to decide and execute an optimized sequence that controls the compressor 2 and valves to reach within a minimum time the target pressure value(s) (TP) in the container(s) (3a, 3b, 3c, 4a, 4b, 4c) calculated by the data processor 35, step of proceeding with refueling of first vehicle 12 when the conditions calculated by data processor 35 are met, provided that H₂ transfer with second nozzle (17) is already finished,

in case of the second refueling process, step of acquiring second residual pressure of the second FCV tank 19 which is connected with the second refueling nozzle 17 and calculating sufficient conditions to achieve complete refueling of second vehicle 18, step of using the conditions calculated by data processor 35 to decide and execute an optimized sequence that controls the compressor 2 and valves to reach within a minimum time the target pressure value(s) (TP) in the container(s) (3a, 3b, 3c, 4a, 4b, 4c) calculated by the data processor 35, step of proceeding with refueling of second vehicle 18 when transfer of H₂ with first nozzle (11) is finished and when the conditions calculated by data processor 35 are met.

[0080] Figure 4 shows flowchart of Embodiment 1. The first refueling process of first FCV 12 is indicated on step 1 to step 8 and on transition 1 to transition 9, and the second refueling process of second FCV 18 is indicated on step 11 to step 18 and on transition 11 to transition 19. Transitions indicate conditions to go from one step to the next one.

[0081] Transition 1: first FCV 12 arrives or is already waiting.

[0082] In step 1, first FCV 12 is positioned within the range of the first hose 10.

[0083] Transition 2: first FCV 12 positioned.

[0084] In step 2, first FCV 12 customer initiates payment by card (if applicable) using the first payment interface in first interface 21.

[0085] Transition 3: payment initiation completed.

[0086] In step 3, customer or operator connects the first refueling nozzle 11 to the first FCV 12.

[0087] Transition 4: nozzle 11 connected to the first FCV tank 13.

[0088] In step 4, pressure in the tank 13 of the first FCV 12 is read by IR communication device or by the pressure sensor 14. Depending on the value, the controller calculates the sufficient pressures in HP buffer banks and/or MP buffers (if any) to achieve successful refueling of the first FCV 12 tank starting with actual tank 13 pressure.

[0089] Transition 5: HP buffer banks and/or MP buffers (if any) have been refilled up to the calculated values. Before proceeding step 5, it is also checked that refueling with second hose 16 is not on-going (i.e. second refueling is not in step 15).

[0090] In step 5, first on-off valve 9 is opened, second on-off valve 15 is closed, first FCV 12 starts refueling. Refueling quantity is shown on the first metering display in first interface 21.

[0091] Transition 6: refueling with first hose (10) terminated.

[0092] In step 6, customer or operator disconnects the first nozzle 11 and place it back on the dispenser 5.

[0093] Transition 7: the first nozzle 11 placed back on dispenser 5.

[0094] In step 7, first FCV 12 customer proceeds to payment using the first payment interface in first interface 21, and first metering display in first interface 21.

[0095] Transition 8: payment completed.

[0096] In step 8, first FCV 12 is moved out of the dispenser 5 area.

[0097] Transition 9: first hose 10 of dispenser 5 area cleared. It is returned to check condition of transition 1. Until a new FCV arrives, first refueling is idle.

[0098] Transition 11: second FCV 18 arrives or is already waiting.

[0099] In step 11, second FCV 18 is positioned within the range of the second hose 16.

[0100] Transition 12: second FCV 18 positioned.

[0101] In step 12, second FCV 18 customer initiates payment by card (if applicable) using the second payment interface in second interface 22.

[0102] Transition 13: payment initiation completed.

[0103] In step 13, customer or operator connects the second refueling nozzle 17 to the second FCV 18.

[0104] Transition 14: second refueling nozzle 17 connected to second FCV tank 19. In step 14, pressure in the tank 19 of the second FCV 18 is read by IR communication device or by the pressure sensor 20. Depending on the value, the controller calculates the sufficient pressures in HP buffer banks and/or MP buffers (if any) to achieve successful refueling of the second FCV 18 tank starting with actual tank 19 pressure.

[0105] Transition 15: HP buffer banks and/or MP buffers (if any) have been refilled up to the calculated values. Before proceeding step 15, it is also checked that refueling with first hose 10 is not on-going (i.e. first refueling is not in step 5).

[0106] In step 15, second on-off valve 15 is opened, first on-off valve 9 is closed, and second FCV 18 starts refueling. Refueling quantity is shown on the second metering display in second interface 22.

[0107] Transition 16: refueling with second hose 16 terminated. In step 16, customer or operator disconnects the second nozzle 17 and place it back on the dispenser 5.

[0108] Transition 17: nozzle 17 placed back on dispenser 5.

[0109] In step 17, the second FCV 18 customer proceeds to payment using the second payment interface in second interface 22, and second metering display in second interface 22.

[0110] Transition 18: payment completed.

[0111] In step 18, the second FCV 18 is moved out of the dispenser 5 area.

[0112] Transition 19: second hose 16 area of dispenser 5 cleared. It is returned to check condition of transition 11. Until a new FCV arrives and first hose area already occupied, second refueling is idle.

[0113] Figures 2 and 3 show a different type of layout of first and second interface 21, 22 in dispenser 5.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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Patent documents cited in the description

- JP2015190596A [0015]
- US6901302B1 [0016]
- US8708005B2 [0017]

Patentkrav

1. Brinttankningssystem, der omfatter:

- 5 Mindst én H₂-forsyningskilde (1), der opbevarer H₂, som har et første tryk,
- en kompressor (2), der er i stand til at øge H₂-tryk, og som kan overføre H₂ fra mindst én beholder, der er valgt fra en MP-buffer (3, 3a, 3b, 3c), en bank (4a, 4b, 4c) eller H₂-forsyningskilden (1) til mindst én anden valgt fra MP-bufferen
- 10 (3, 3a, 3b, 3c) og banken (4a, 4b, 4c),
- én eller flere HP-bufferbanke, herunder mindst én bank (4a, 4b, 4c), der opbevarer H₂ under forskellige tryk, generelt højere end trykket i H₂-forsyningskilden (1),
- Eventuelt én eller flere MP-buffer (3, 3a, 3b, 3c), der
- 15 opbevarer H₂ under et tryk, der generelt er højere end trykket i H₂-forsyningskilden (1) og generelt lavere end trykket i HP-bufferbanken(e),
- Mindst én dispenser (5), der kan overføre H₂ fra mindst én beholder, der er valgt blandt H₂-forsyningen (1), MP-bufferen
- 20 (3, 3a, 3b, 3c) og banken (4a, 4b, 4c) og/eller fra kompressorens (2) udløb til tanken på et køretøj,
- eventuelt én varmeveksler (8), der kan nedkøle H₂, inden det overføres til tanken på køretøjet, og som forsynes med en kølevæske,
- 25 en første regulator (30), der styrer kompressoren (2), og én eller flere ventiler, der sidder på rør på en sådan måde, at der, når stationen er stillestående, afhængigt af forudbestemte operationstrin, overføres H₂ fra mindst én beholder, der er valgt fra H₂-forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c)
- 30 og banken (4a, 4b, 4c), til en anden mindst ene beholder, der er valgt fra MP-bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c), op til det eller de forudbestemte måltryk (Pset) i modtagende beholdere, der er valgt fra mindst én fra MP-bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c),
- 35 en dataprocessor (35), der, når der er tilsluttet ét køretøj, som skal tankes, aflæser residualtrykket i køretøjets tank (13, 19) ved hjælp af dyse (11, 17) IR-kommunikationsapparat eller trykføler (14, 20) og, afhængigt af residualtryk i køretøjets

tank (13, 19), og/eller afhængigt af trykket i beholderne, herunder mindst én beholder, der er valgt fra H2-forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c), og/eller afhængigt af omgivende temperatur beregner

5 måltrykværdi(er) (TP) i én eller flere beholdere, herunder mindst én beholder, der er valgt fra H2-forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c), der er tilstrækkelige betingelser til at opnå fuldstændig tankning af det tilsluttede køretøj,

10 en anden regulator (40), der, når der er tilsluttet ét køretøj til tankning, bruger de betingelser, der er beregnet af dataprocessoren (35), til at bestemme og udføre en sekvens, der styrer kompressoren (2) og ventilerne for at opnå måltrykværdi(er) (TP) i beholderen/beholderne, herunder mindst

15 én beholder, der er valgt fra H2-forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c), der er beregnet af dataprocessoren (35),

en tredje regulator (45), der, når de betingelser, der er beregnet af dataprocessoren (35), er opfyldt, styrer

20 kompressoren (2) og ventilen/ventilerne i henhold til en forudbestemt strategi og tankningsprotokol på en sådan måde, at der overføres H2 fra den mindst ene beholder, der er valgt fra H2-forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c), til køretøjets beholder, hvor sekvensen bestemmes

25 på en sådan måde, at den tid, hvor det er muligt at opnå de betingelser, der blev beregnet af dataprocessoren (35) efter tilslutning af tankningsdysen (11, 17) til køretøjet, er en minimumstid.

30 2. Systemet ifølge krav 1, hvor den mindst ene dispenser (5) omfatter:

en styreventil (6), der er placeret på en hovedrørledning (57), som H₂ sendes gennem fra beholderne,

et doseringsapparat (7), der er placeret på hovedrørledningen

35 (57),

en varmeveksler (8), der er placeret på hovedrørledningen (57), og som nedkøler eller opvarmer H₂ gennem hovedrørledningen (57), første og andre forgreningsrørledninger (57a, 57b), som

forgrener sig fra hovedrørledningen (57),
en første start/stop-ventil (9), der er placeret på den første
forgreningsrørledning (57a),
en anden start/stop-ventil (15), der er placeret på den anden
5 forgreningsrørledning (57b),
en første slange (10), der har en første tankningsdyse (11) i
den ene ende og er tilsluttet til den første
forgreningsrørledning (57a) i den anden ende, og
en anden slange (16), der har en anden tankningsdyse (17) i den
10 ene ende og er tilsluttet til den anden forgreningsrørledning
(57b) i den anden ende.

3. Systemet ifølge krav 1 eller 2,
hvor den tredje regulator (45) kan styre en første
15 tankningsproces, der er konfigureret til at tanke H₂ gennem den
første slange (10) fra den første tankningsdyse (11) i den første
FCV-tank (13) i det første køretøj (12), og/eller
den tredje regulator (45) kan styre en anden tankningsproces,
der er konfigureret til at tanke H₂ gennem den anden slange (16)
20 fra den anden tankningsdyse (17) i den anden FCV-tank (19) i det
andet køretøj (18),
i tilfælde af en første tankningsproces
kan dataprocessoren (35) hente det første residualtryk for den
første FCV-tank (13), der er forbundet til den første
25 tankningsdyse (11), og som kan beregne tilstrækkelige
betingelser til at opnå fuldstændig tankning af det første
køretøj (12),
den anden regulator (40) kan bruge de betingelser, der er
beregnet af dataprocessoren (35), til at bestemme og udføre en
30 sekvens, der styrer kompressoren (2) og ventilerne for at opnå
målttrykværdi(er) (TP) i beholderen/holderne, herunder mindst
én beholder, der er valgt fra H₂-forsyningskilden (1), MP-
bufferen 3(3a, 3b, 3c) og banken (4a, 4b, 4c), der er beregnet
af dataprocessoren (35),
35 når de betingelser, der er beregnet af dataprocessoren (35) er
opnået, og forudsat at
overførslen af H₂ med den anden dyse (17) allerede er afsluttet,
kan den tredje regulator (45) fortsætte med at tanke det første

køretøj (12),
i tilfælde af den anden tankningsproces
kan dataprocessoren (35) hente det andet residualtryk for den
anden FCV-tank (19), der er forbundet til den anden
5 tankningsdyse (17), og som beregner tilstrækkelige betingelser
til at opnå fuldstændig tankning af det andet køretøj (18),
kan den anden regulator (40) bruge de betingelser, der er
beregnet af dataprocessoren (35), til at bestemme og udføre en
sekvens, der styrer kompressoren (2) og ventilerne for at opnå
10 måltrykværdi(er) (TP) i beholderen/holderne, herunder mindst
én beholder, der er valgt fra H₂-forsyningskilden (1), MP-
bufferen (3, 3a, 3b, 3c) og banken (4a, 4b, 4c),
der er beregnet af dataprocessoren (35),
når overførslen af H₂ med den første dyse (11) er fuldført, og
15 når de betingelser, der er beregnet af dataprocessoren (35), er
opnået, kan den tredje regulator (45) fortsætte med at tanke det
andet køretøj (18).

4. Fremgangsmåde, der anvender brinttankningssystemet ifølge
20 krav 3 til at udføre en første tankningsproces, der tanker H₂ til
den første FCV-tank (13) i det første køretøj (12), og en anden
tankningsproces, der tanker H₂ til den anden FCV-tank (19) i det
andet køretøj (18), idet det første og andet køretøj (12,18)
standsnes i tankningsintervallet for kun én dispenser (5), der
25 omfatter:

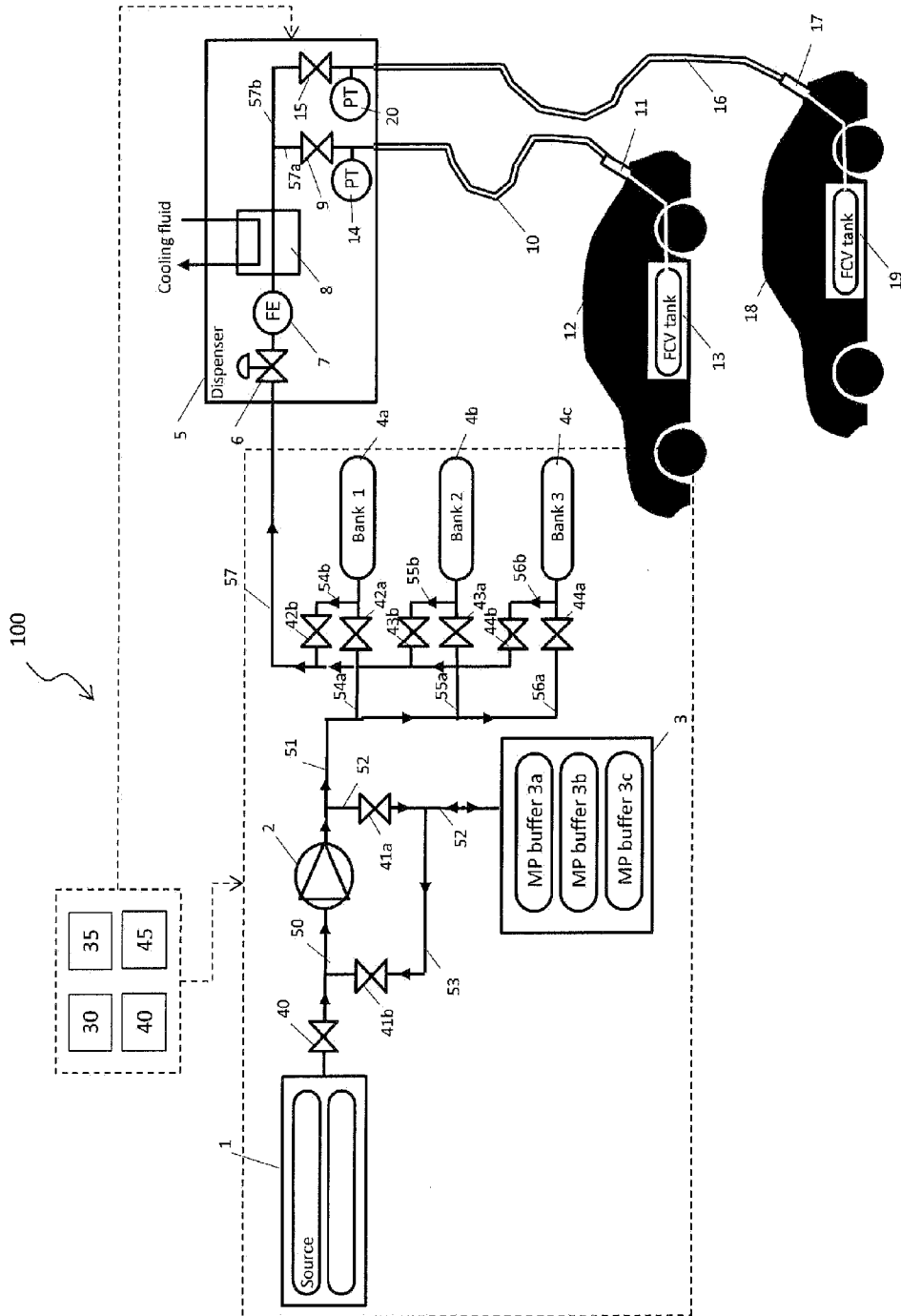
i tilfælde af en første tankningsproces
hentning af det første residualtryk for den første FCV-tank
(13), der er forbundet til den første tankningsdyse (11), og
beregning af tilstrækkelige betingelser til at opnå fuldstændig
30 tankning af det første køretøj (12),
brug af de betingelser, der er beregnet af dataprocessoren (35),
til at bestemme og udføre en sekvens, der styrer kompressoren
(2) og ventilerne for at opnå måltrykværdi(er) (TP) i
beholderen/holderne, herunder mindst én beholder, der er valgt
35 fra H₂-forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c) og
banken (4a, 4b, 4c), der er beregnet af dataprocessoren (35),
fortsættelse med tankning af det første køretøj (12), når de
betingelser, der er beregnet af dataprocessoren (35) er opnået,

og forudsat at
overførslen af H₂ med den anden dyse (17) allerede er afsluttet,
i tilfælde af den anden tankningsproces
hentning af det andet residualtryk for den anden FCV-tank (19),
5 der er forbundet til den anden tankningsdyse (17), og beregning
af tilstrækkelige betingelser til at opnå fuldstændig tankning
af det andet køretøj (18),
brug af de betingelser, der er beregnet af dataprocessoren (35),
til at bestemme og udføre en sekvens, der styrer kompressoren
10 (2) og ventilerne for at opnå måltrykværdi(er) (TP) i
beholderen/beholderne, mindst én beholder, der er valgt fra H₂-
forsyningskilden (1), MP-bufferen (3, 3a, 3b, 3c) og banken (4a,
4b, 4c), der er beregnet af dataprocessoren (35),
fortsættelse med tankning af det andet køretøj (18), når
15 overførslen af H₂ med den første dyse (11) er fuldført, og når
de betingelser, der er beregnet af dataprocessoren (35), er
opnået.

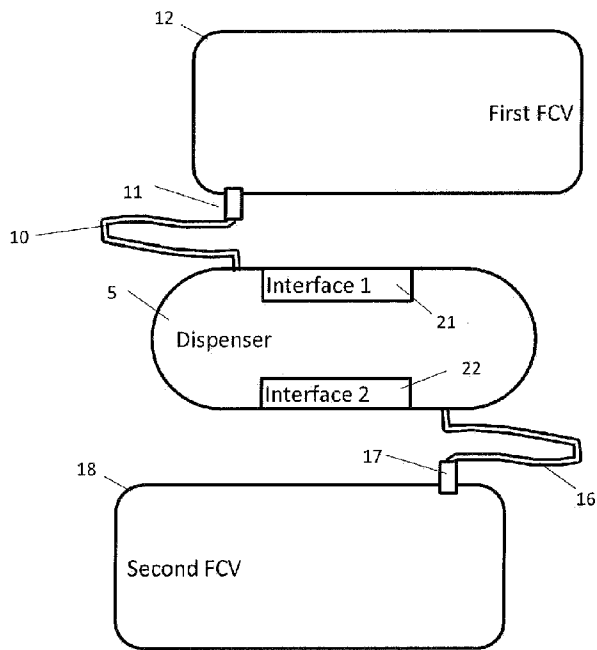
DRAWINGS

Drawing

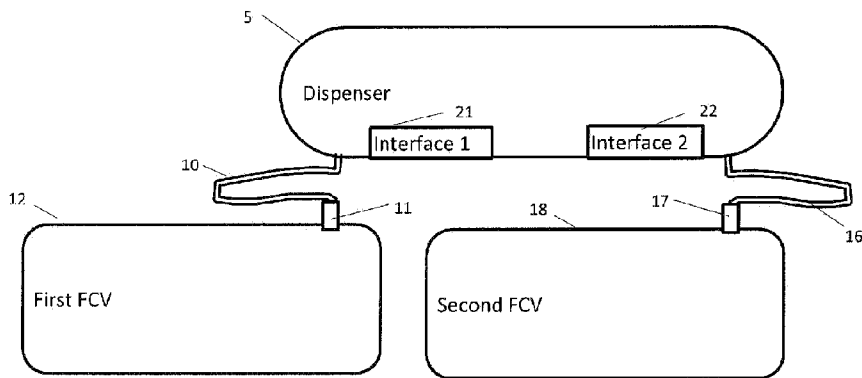
[Fig. 1]



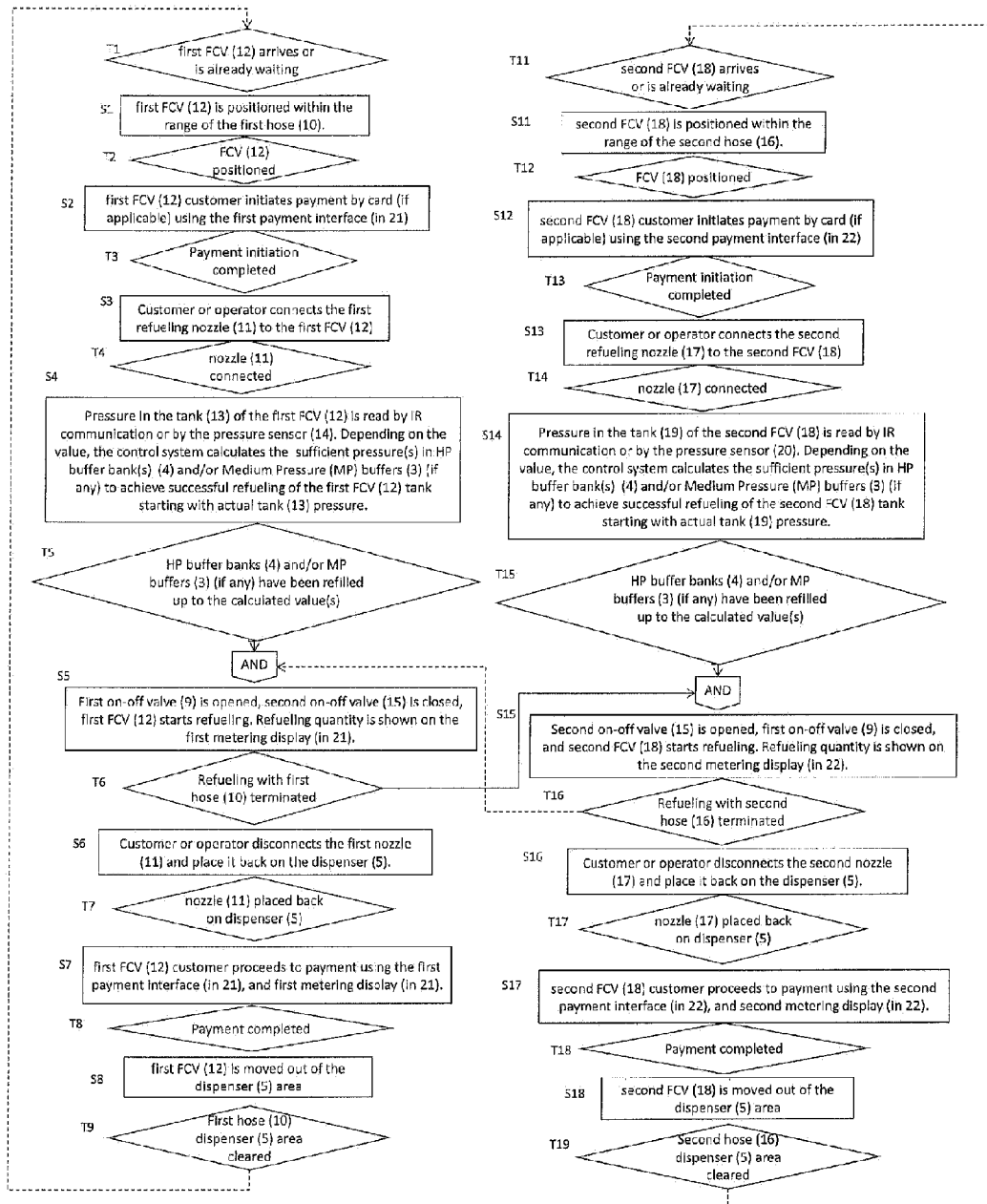
[Fig. 2]



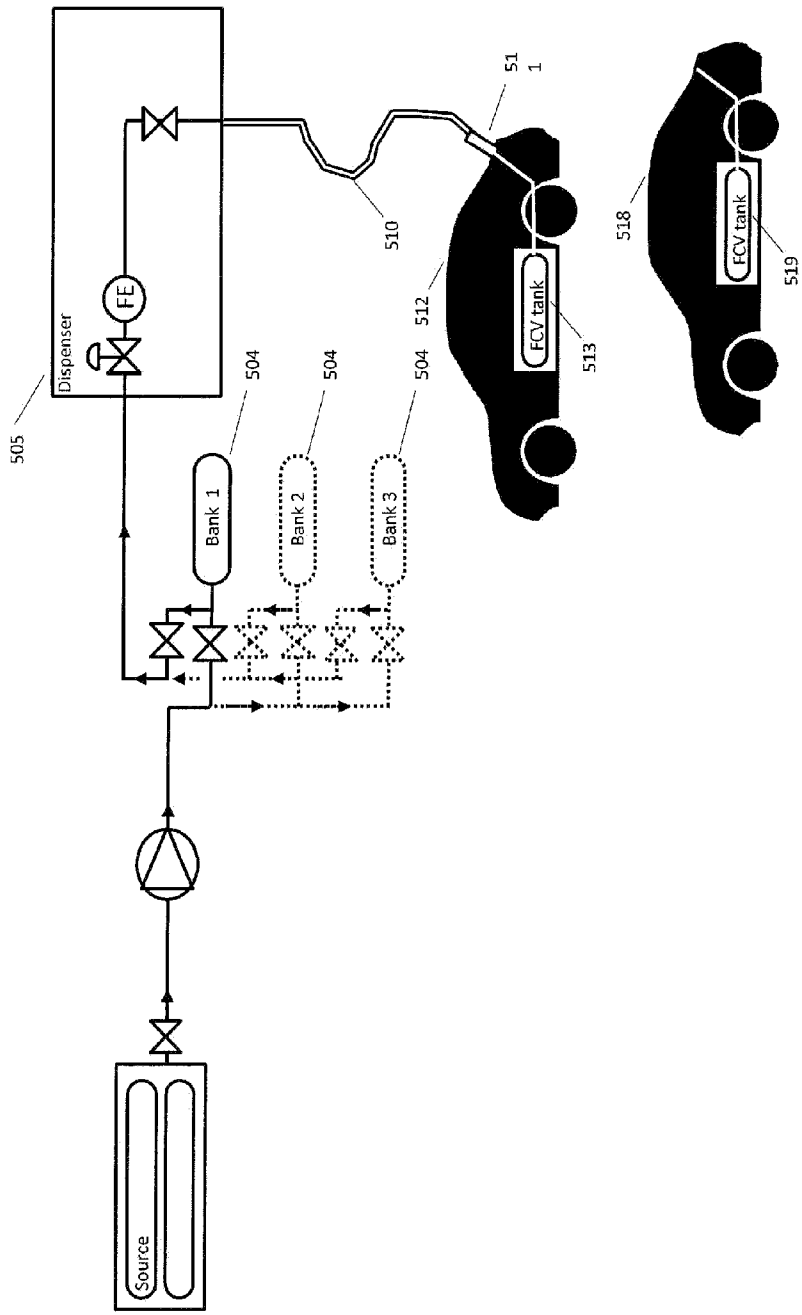
[Fig. 3]



[Fig. 4]



[Fig. 5A]



[Fig. 5B]

