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(54) Gasoline dispensing and vapor recovery system and method utilizing a membrane separator

(57) A gasoline dispensing and vapor recovery system and method in which a mixture of air and hydrocarbon vapor is recovered from the vehicle being refueled from a gasoline storage tank and is passed, under pressure, to a separator to separate the air from the gasoline vapor in the mixture. The separated air is vented to the atmosphere and the hydrocarbon vapor passes through the separator and to the gasoline storage tank. As a result, the build-up of excessive air and vapor in the system is prevented.

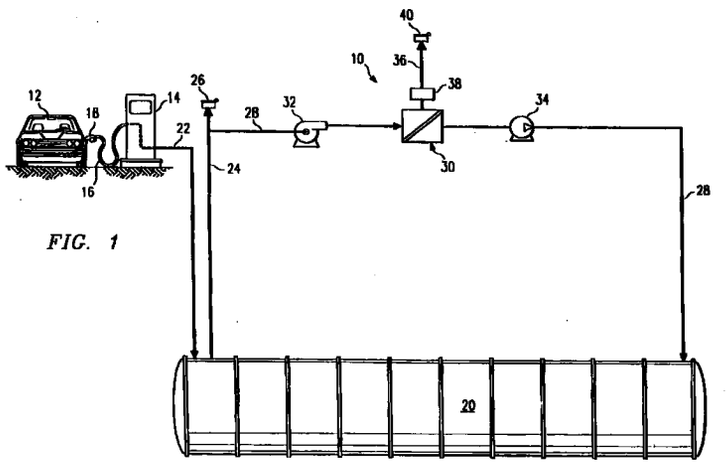


FIG. 1

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Description

Background of the Invention

The present invention relates to a gasoline dispensing and vapor recovery system and method and, more particularly, to such a system and method utilizing a semi-permeable membrane separator to separate the air from the hydrocarbon vapor in the recovered air-vapor mixture.

Systems for recovering hydrocarbon vapor from the mixture of air and vapor displaced from a vehicle tank during the dispensing of gasoline into the tank are well known. According to a great number of these systems, the collected air-vapor mixture is recovered by the gasoline dispensing nozzle and passed to the ullage portion of an underground storage system for the gasoline where it is assumed that condensation of the mixture will occur, and therefore only relatively small amounts of the mixture will be emitted to the atmosphere through a vent pipe associated with the underground storage system.

However, the air-vapor mixture often contains significant amounts of air, especially in connection with "vacuum assist" vapor recovery systems that are designed to achieve a high vapor recovery efficiency and improved product delivery rates. Therefore, a relatively large portion of the mixture is often not condensed in the storage tank and the air becomes saturated causing a build-up of the air-vapor mixture in the tank. This results in unacceptable levels of the mixture to be discharged into the atmosphere from the vent pipe along with fugitive emissions from the latter tank and its associated fixtures and components.

These problems are especially acute when the vehicles have to be equipped with carbon canisters that trap the vapor in the vehicle during refueling, in compliance with certain regulations. When this occurs, the vapor recovery system processes an air-vapor mixture that is substantially air and returns it to the underground storage tank. Since most vapor recovery systems are not equipped to recognize this situation, the air-laden mixture is returned to the underground tank and causes the problems discussed above.

Therefore what is needed is a gasoline dispensing and vapor recovery system in which a great majority, if not all, of the recovered air-vapor mixture is voided of air to prevent the build-up of the mixture in the underground storage tank.

Summary of the Invention

The present invention, accordingly, provides a system and method in which the air portion of the air-vapor mixture is removed from the mixture prior to the latter being introduced back into the storage tank. As a result, a relatively high percentage of the remaining mixture which is primarily hydrocarbon vapor, is condensed and the growth of the mixture in the storage tank is prevented.

To this end, according to the present invention, the recovered air-gasoline vapor mixture is passed from the underground storage tank to an air-vapor separator under pressure provided by a blower connected in a conduit connecting the storage tank to the separator. The separator includes a semi-permeable membrane which has greater permeability to organic vapor than to air and thus rejects the air while allowing the vapor to pass through. The separated air is discharged into the atmosphere and the vapor is passed back to the underground storage tank.

Thus, a major advantage is achieved with the system and method of the present invention since essentially gasoline and concentrated hydrocarbon vapor is returned to the storage tank, and since the vapor readily condenses in the tank, the above-described problems of the prior systems are eliminated.

Brief Description of the Drawings

Figure 1 is a schematic representation of the system of the present invention.

Figure 2 is a schematic representation, similar to figure 1, but depicting optional features of the system of the present invention.

Description of the Preferred Embodiments

Referring to Fig. 1 of the drawings, the reference numeral 10 refers, in general, to the system of the, present invention which is designed to recover a mixture of air and gasoline vapors from the gasoline tank of a vehicle 12 while gasoline is being dispensed into the tank from a dispensing unit 14, of the type utilized at a service station. To this end, a hose 16 extends from the dispensing unit, and a nozzle 18 is connected to the distal end of the hose and is adapted to be inserted into the fill neck of the gasoline tank of the vehicle 12 to discharge gasoline into the tank.

A gasoline storage system 20, preferably in the form of an underground storage tank, is provided for storing the gasoline and for receiving the air-vapor mixture displaced from the tank of the vehicle 12 when the gasoline is dispensed into the latter tank, as will be described. The plumbing, piping and the like for introducing the gasoline from the storage tank 20 into the tank of the vehicle 12 is not shown so that the vapor recovery system of the present invention can be better emphasized.

More particularly, the nozzle 18, and therefore the hose 16, receive the displaced air-vapor mixture from the tank of the vehicle 12 during the dispensing operation. In this context, it is understood that a "balanced" system can be used to recover the vapor as disclosed in U.S. Patent Nos. 4,566,504; 4,687, 033; and 4,978,504. Alternatively, a "vacuum assist" system can be used as disclosed in U.S. Patent Nos. 5,038,838; 5,040,577; and 5,105,5654.

A conduit, or pipe 22, is connected to the hose 16 in any known manner in the dispensing unit 14 and projects from the latter unit. The conduit 22 extends to an appropriate inlet opening in the storage tank 20 for transferring the displaced air-vapor mixture from the tank of the vehicle 12 to the storage tank.

A standard vent pipe 24 extends outwardly from an outlet opening in the storage tank 20 for venting the tank. To this end, a pressure/vacuum valve 26 is disposed on the discharge end of the vent pipe 24 and functions in a conventional manner to maintain a predetermined pressure in the system, and permit venting only when the pressure in the tank 20 exceeds this pressure, as will be described.

A conduit 28 is connected to the vent pipe 26 and extends back to an inlet opening in the storage tank 20 which is in a spaced relationship to the outlet opening. Thus, an air-vapor mixture from the storage tank 20 can be circulated through the vent pipe 24, the conduit 28, and back to the storage tank, as will be described.

A membrane separator 30 is connected to the conduit 28 in the path of the air-vapor mixture as it circulates through the conduit 28 and includes a semi-permeable membrane extending in the path of the mixture. The separator 30 is substantially permeable to organic vapors but substantially impermeable to air so that the air in the air-vapor mixture is rejected by the membrane and thus separated from the vapor as the latter passes through the separator 30. Numerous membrane separators that can be used to perform this function are fully disclosed in U.S. patent No. 4,553,983 and No. 4,659,343 the disclosures of which are incorporated by reference. The preferred composition of the membrane that is used in the present system and method is an organic polymer similar to buna, but may be a variety of alternative polymers, either organic or inorganic. Although the preferred configuration of the membrane is spiral-would, it could be polymer-coated hollow tube fibers. Similarly, although the preferred housing material is stainless steel, any alternative housing material may be used which is impervious to gasoline vapor and other vapors which may be present in the recovered mixture.

A blower 32 is disposed in the conduit 28 between the vent pipe 24 and the separator 30. The blower 32 is designed to create, and continuously maintain, a predetermined pressure in this portion of the conduit 28, that is, in the portion on the inlet side of the separator 30, to promote the flow of the air-vapor mixture from the storage tank 20, into and through the conduit 28 and towards the separator 30. A vacuum unit 34, preferably in the form of a vacuum pump, is disposed in the conduit 28 between the separator 30 and the inlet opening of the storage tank 20 to maintain a relative high vacuum on the discharge side of the separator. This establishes a pressure differential across the separator to pull the air-vapor mixture onto the separator and the separated vapor through the membrane and back to the storage tank 20.

A discharge conduit 36 extends from the outlet side of the membrane separator 30 for discharging the separated air from the housing separator into the atmosphere. A hydrocarbon detector 38 is connected in the conduit 36 and operates in a conventional manner to respond to the presence of a predetermined amount of gasoline vapor in the conduit indicative of a malfunction of the separator 30, a system overload, or the like, to actuate a signal and/or shut the system down. A valve 40 is provided at the discharge end of the conduit 36 and opens in response to the pressure on the inlet side of the membrane separator 30 attaining a predetermined value, as will be described.

In operation, the blower 32 operates continuously to maintain a predetermined pressure, such as 0.1-1.5 psig, on the inlet side of the separator 30 to draw the air-vapor mixture from the storage tank 20 into the conduit 28. The vacuum unit 34 maintains a vacuum, such as 25-30 inches of mercury, on the discharge end of the separator 30 such that the ratio of the discharge pressure to the inlet pressure with respect to the membrane 34 is approximately 8. This establishes a significant pressure differential across the separator 30 which forces the air-vapor mixture onto its membrane. Substantially all of the air in the air-vapor mixture is rejected by the membrane separator 30 and the remaining portion of the mixture, which is substantially gasoline vapor, passes through the separator and flows, via the remaining portion of the conduit 28, back to the storage tank 20. The rejected air passes through the discharge conduit 36, and the valve 40 is designed to open at 2-6 inches of water to vent the air to the atmosphere. The permeate from the discharge end of the separator 30, which consists of gasoline and concentrated vapor, is discharged into the ullage portion of the tank 20.

The valve 26 opens only in the event of a system breakdown to relieve excess pressure in the storage tank 20 to the atmosphere.

The advantages of the present invention are many. For example, a substantial amount of the air in the air-vapor mixture is separated from the gasoline vapor. Therefore, the great majority of the mixture returned to the storage tank 20 from the separator 30 is gasoline and gasoline vapor which readily condenses in the tank, thereby eliminating vapor growth in the latter tank. Thus, vapor loss at the refueling nozzle 18 is reduced, fugitive emissions from the storage tank 20 are eliminated, and the CARB efficiency of the vapor recovery system 10, as defined by the California Air Resources Board, is increased to values greater than 99%.

Figure 2 of the drawings depict a vapor recovery system 50 which is similar to the system 10 of figure 1, but include several additional features. Since several components of the system 50 are identical to those of the system 10, they will be given the same reference numerals and will not be described again.

The system 50 features three underground storage tanks 20a, 20b, and 20c which are connected together by a manifold conduit 52 extending from the conduit 28.

More particularly, the conduit 28 extends to the tank 20c and the manifold conduit 52 has two branch conduits 52a and 52b extending therefrom which respectively extend to the tanks 20a and 20b. The tank 20a receives the conduit 22 and the vent pipe 24 which function in the same manner as in the previous embodiment.

As a result of the above common connections to the conduit 28, the tanks 20a, 20b, and 20c can be maintained at the same internal pressure and thus, for the purposes of the invention, operate as one tank. This enables the tanks 20a, 20b and 20c to contain different grades of gasoline which can be passed to, and selected at, the dispensing unit 14.

The system 50 also includes a sensor 54 is provided in the tank 20a for sensing the vapor pressure in the latter tank and is connected, via an electrical conductor 56a, to a switch 58 which, in turn, is connected, via a conductor 56b, to the vacuum pump 34. The switch 58 operates in a conventional manner to selectively actuate the pump 34 when a predetermined pressure condition, as sensed by the sensor 54, exists in the tank 20a, and therefore the tanks 20b and 20c. This enables the pressure in the tanks 20a, 20b and 20c to be regulated without resorting to a valve, or the like associated with the vent pipe 24, and permits the use of diagnostics, or the like, to annunciate alarms or shut the system 10 down in the event a malfunction occurs. It is understood that the sensor 54 and the switch 58 could also be connected to the blower 32 and function in an identical manner.

According to another feature of the system 50, a thermal condenser 62 is connected in the conduit 28 on the discharge side of the separator 30 to convert the vapor in the air-vapor mixture to liquid after it exits the separator 30 and before it is introduced to the tank 20c.

The system 50 also includes a bypass branch conduit 36a which extends from the discharge conduit 36 for recycling the air rejected by the membrane separator 30 back to the inlet portion of the conduit 28. In this context, a valve 64 is provided in the conduit 36 and is electrically connected, via a conductor 66, to the hydrocarbon detector 38 so that, upon receiving a signal from the detector 38 indicating that too much gasoline vapor is in the conduit 36, the valve functions to route the air-vapor mixture through the bypass conduit 36a. The mixture would thus be reintroduced into the separator 30 to remove the gasoline vapor from the mixture.

Finally, the discharge end portion of the conduit 28 can extend to the lower portion of the tank 20c to promote condensation of the gasoline vapor introduced into the latter tank.

It is understood that a logic control unit (not shown) is provided which senses all operating conditions of the various components described above and controls their operation in accordance with particular predetermined design requirements. This logical control unit could also communicate with a similar unit in the associated gasoline dispensing system to optimize product delivery and corresponding rates of vapor recovery. Since these units, per se, do not form a part of the present invention, they are not shown nor will they be further described.

It is also understood that each of the above-described features of the system 50 are optional and can be used separately or together in various combinations.

Variations in the foregoing can be made without departing from the scope of the invention. For example, the single tank arrangement of the system 10 of figure 1 can be used with one or more of the additional optional features of the system 50 of figure 2 without departing from the scope of the invention. Also, the present invention is not limited to the use of one membrane separator, but can use two or more in series to achieve higher system separation or in parallel to achieve higher system capacity. In this context, a backup membrane separator could be provided that the system would automatically switch to under certain conditions such as, for example, the failure of the primary membrane separator causing an excessive amount of hydrocarbons to be detected by the detector 38, etc. Further, the sensor 54 and the switch 58 can be part of the above-mentioned logic control unit which would include the detector 38 and would function to annunciate alarms or perform system shutdown in the event of a malfunction. Moreover, the sensor 54 can be located in various areas of the system other than at the storage tank 20 and/or additional sensors can be provided which function in the same manner.

Still other variations may be made in the both of the foregoing embodiments without departing from the scope of the present invention. For example, the specific construction and arrangement of the various conduits may be varied within the scope of the invention. Also, the conduits 22 and 28 could be in the form of pipes, hoses, or the like which extend continuously or which are formed of separate shorter pipes, hoses, or the like connected together, all in a conventional manner. Further, the conduit 22 could be connected directly to the vent pipe 24 (as shown by the dashed lines in figure 2) so that the recovered air-vapor mixture would pass directly from the dispensing unit 14 to the separator 30 without passing through the storage tank 20.

It is understood that other modifications, changes and substitutions are intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. A gasoline dispensing and vapor recovery system comprising a dispensing system for dispensing gasoline from a storage tank to a vehicle tank, a system for recovering a mixture of gasoline vapor and air from the vehicle tank as a result of the dis-

pensing of the gasoline, a first conduit for receiving the mixture of gasoline vapor and air, a separator for receiving the mixture of gasoline vapor and air from the conduit and for separating the vapor in the mixture from the air in the mixture, a pressure unit for pressurizing the mixture and promoting the flow of the mixture through the conduit and to the separator, and a second conduit for passing the separated vapor from the separator to the storage tank.

2. The system of claim 1 wherein the mixture recovery system connects the vehicle tank to the storage tank for passing the mixture displaced from the vehicle tank during the dispensing to the storage tank, and wherein the first conduit connects the storage tank to the separator for passing the mixture from the storage tank to the separator.

3. The system of claim 1 wherein the pressure unit is a blower disposed in the first conduit.

4. The system of claim 1 or 3 further comprising a unit disposed in the second conduit to induce the flow of the separated vapor from the separator, through the second conduit, and to the storage tank.

5. The system of claim 1 further comprising a condenser disposed in the second conduit for condensing the separated vapor before it is returned to the storage system.

6. The system of claim 1 wherein the second conduit passes separated vapor into the lower portion of the storage system and into the gasoline stored therein.

7. The system of claim 1 wherein the vehicle tank is filled by a nozzle extending from a dispensing unit of a service station and where the recovery system comprises a conduit extending from the nozzle to the dispensing unit for receiving the mixture displaced from the vehicle tank during the dispensing of the gasoline to the vehicle tank, the first conduit extending from the dispensing unit to the storage tank.

8. The system of claim 7 further comprising a vacuum unit disposed in the dispensing unit for establishing a vacuum to promote the flow of the mixture to the separator.

9. The system of claim 1 further comprising at least one additional storage tank, and wherein the second conduit is connected to each of the storage tanks.

10. The system of claim 1 further comprising a discharge pipe associated with the separator for discharging the separated air to atmosphere.

11. The system of claim 10 further comprising a conduit for returning the separated air from the discharge pipe back to the separator.

12. The system of claim 1 wherein the separator comprises a membrane which is permeable to the gasoline vapor and impermeable to air.

13. A gasoline dispensing and vapor recovery system comprising a dispensing system for dispensing gasoline from a storage tank to a vehicle tank, a system for recovering a mixture of gasoline vapor and air from the vehicle tank as a result of the dispensing of the gasoline, a separator for receiving the mixture and capturing the air in the mixture while allowing the vapor in the mixture to pass from the separator, and a conduit for passing the vapor from the separator to the storage, tank.

14. The system of claim 13 wherein the mixture recovery system connects the vehicle tank to the storage tank for passing the mixture displaced from the vehicle tank during the dispensing to the storage tank, and further comprising a conduit for passing the mixture from the storage tank to the separator.

15. The system of claim 14 further comprising a blower disposed in the latter conduit for establishing a pressure to promote the flow of the mixture from the storage tank to the separator, and to maintain an optimum inlet pressure.

16. The system of claim 13 or 15 further comprising a unit disposed in the first-mentioned conduit to promote the flow of the separated vapor through the separator and to the storage tank.

17. The system of claim 13 further comprising a condenser disposed in the conduit for condensing the separated vapor before it is returned to the storage system.

18. The system of claim 13 wherein the conduit passes separated vapor into the lower portion of the storage system and into the gasoline stored therein.

19. The system of claim 13 wherein the vehicle tank is filled by a nozzle extending from a dispensing unit of a service station and where the recovery system comprises a conduit extending from the nozzle to the dispensing unit for receiving the mixture displaced from the vehicle tank during the dispensing of the gasoline to the vehicle tank, and a conduit extending from the dispensing unit to the storage tank.

20. The system of claim 19 further comprising a vacuum unit disposed in the dispensing unit for establishing a vacuum to promote the flow of the mixture

to the separator.

21. The system of claim 13 further comprising at least one additional storage tank, and wherein the conduit is connected to each of the storage tanks.

22. The system of claim 13 further comprising a discharge pipe associated with the separator for discharging the separated air to atmosphere.

23. The system of claim 22 further comprising a conduit for returning the separated air from the discharge pipe back to the separator.

24. The system of claim 1 wherein the separator comprises a membrane which is permeable to the gasoline vapor and impermeable to air.

25. A vapor recovery method comprising the steps of dispensing gasoline from a storage system into a tank, recovering a mixture of air and gasoline vapor displaced from the tank, pressurizing the mixture of air and gasoline vapor, then separating the vapor in the mixture from the air in the mixture, and passing the separated vapor to the storage system.

26. The method of claim 25 wherein the step of recovering is during the step of dispensing.

27. The method of claim 24 further comprising the steps of passing the recovered mixture to the storage system before the step of pressurizing, and passing the recovered mixture from the storage system during the step of pressurizing.

28. The method of claim 25 further comprising the step of promoting the flow of the separated vapor to the storage system.

29. The method of claim 25 further comprising the step of condensing the separated vapor before it is returned to the storage system.

30. The method of claim 25 further comprising the step of discharging the separated air to atmosphere.

31. The method of claim 25 further comprising the step of returning the separated air back to the mixture.

32. A vapor recovery method comprising the steps of dispensing gasoline from a storage system into a tank, recovering a mixture of air and gasoline vapor displaced from the tank, separating the air from the mixture while passing the vapor in the mixture to the storage system.

33. The method of claim 32 wherein the step of recovering is during the step of dispensing.

34. The method of claim 32 further comprising the step of pressurizing the mixture before the step of separating.

35. The method of claim 34 further comprising the steps of passing the recovered mixture to the storage system before the step of pressurizing, and passing the recovered mixture from the storage system during the step of pressurizing.

36. The method of claim 32 further comprising the step of promoting the flop of the separated vapor to the storage system.

37. The method of claim 32 further comprising the step of condensing the separated vapor before it is returned to the storage system.

38. The method of claim 32 further comprising the step of discharging the separated air to atmosphere.

39. The method of claim 32 further comprising the step of returning the separated air back to the mixture.

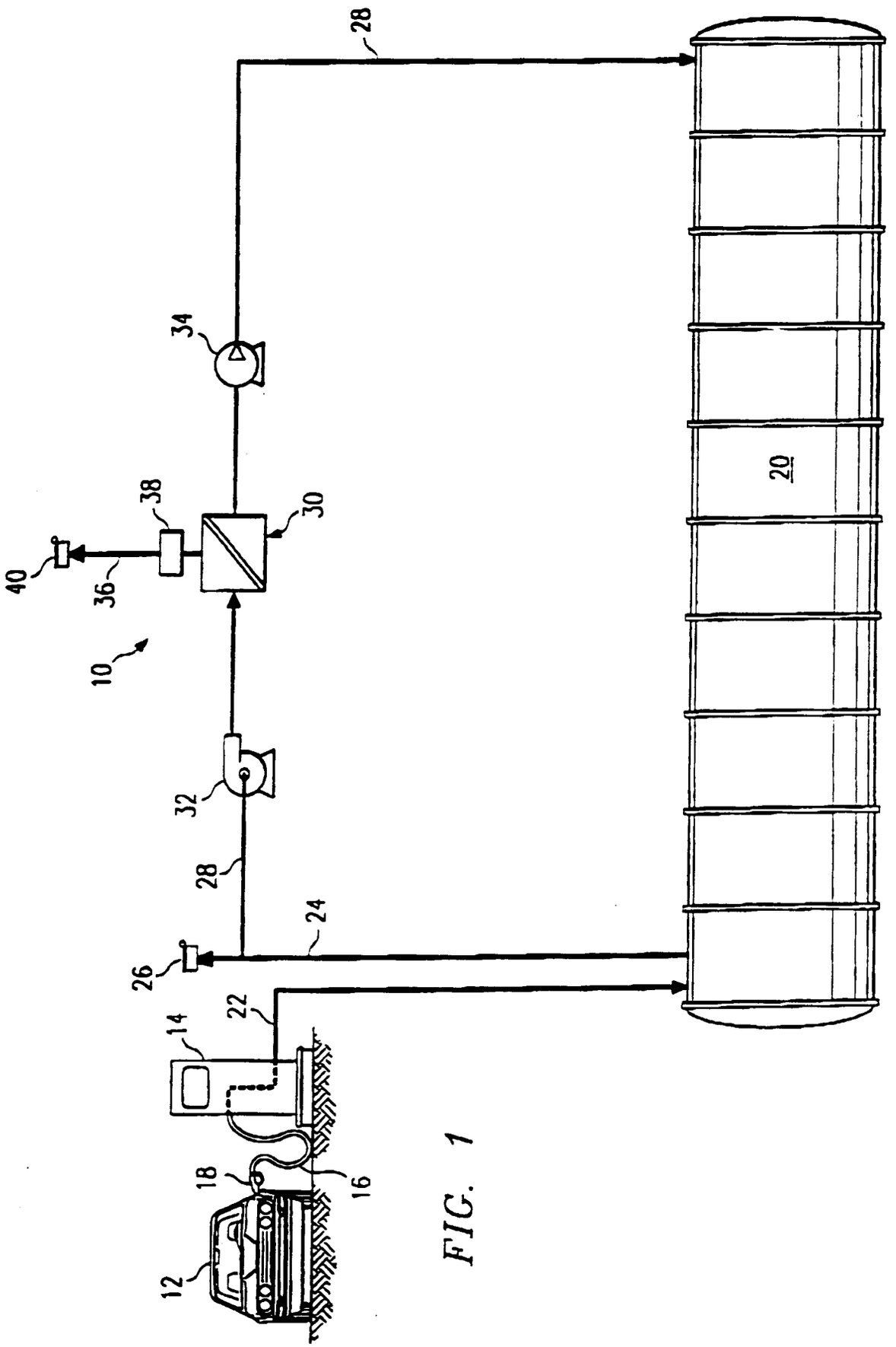


FIG. 1

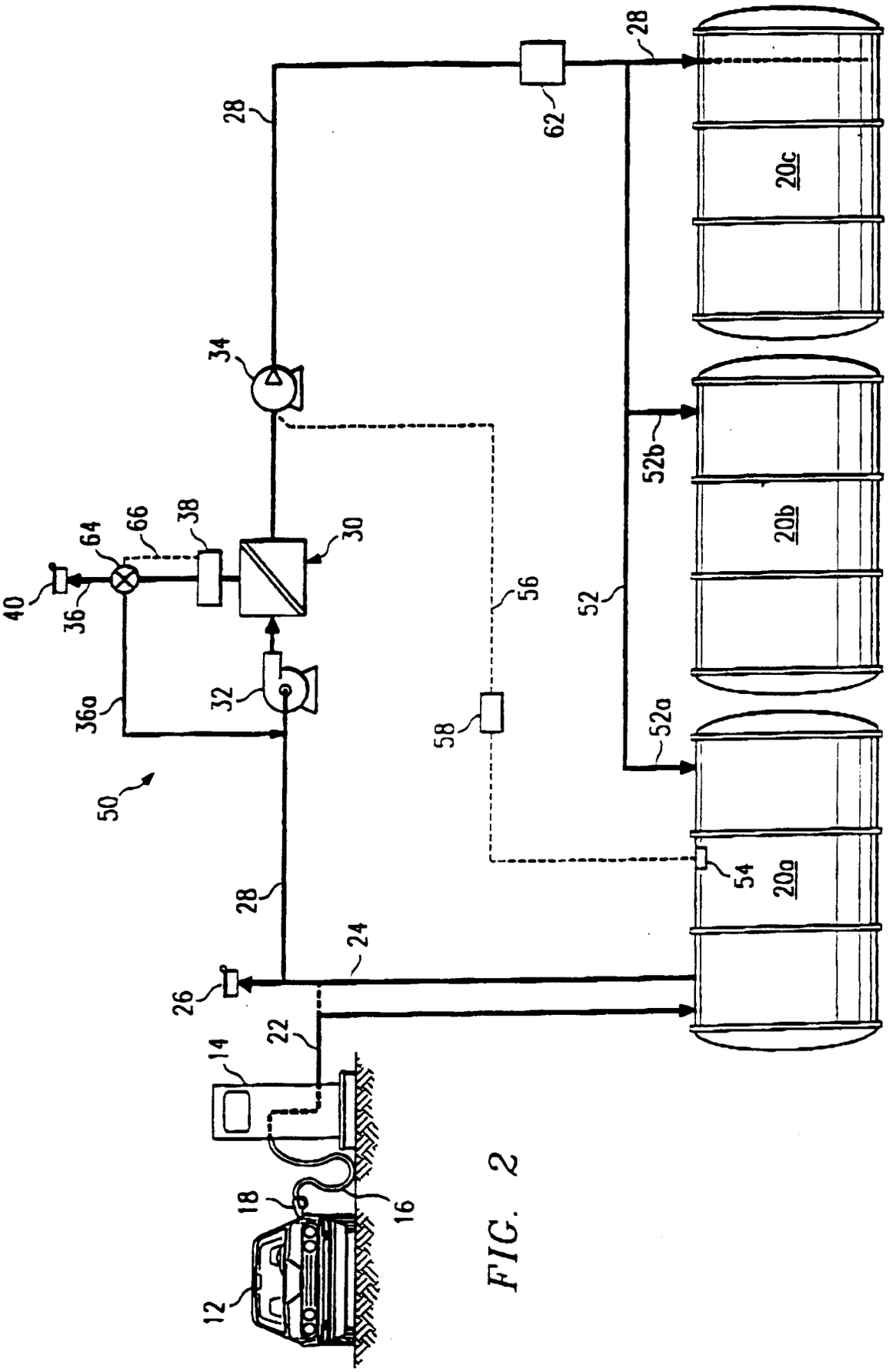

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FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 5532

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	WO 95 13984 A (GILBARCO LTD.) * page 5, line 17 - page 6, line 13 * * page 7, line 17 - page 8, line 15 * * figure 1 *	1,2,4,7,10,12,25-28,30 3,5,9,11,29,31	B67D5/04
Y	US 3 999 936 A (D. HASSELMAN) * figure 1 * * column 5, line 52 - line 62 *	3	
Y	US 3 815 327 A (C. VILAND) * column 3, line 37 - column 5, line 6 * * figure *	5,29	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 July 1997	Smolders, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 5532

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 42 14 424 A (OSCAR GOSSLER KG) * column 1, line 64 - column 2, line 20 * * figure * ---	1,6,10, 12,25, 26,30	
A	DE 44 10 597 A (GKSS-FORSCHUNGSZENTRUM GEESTHACHT GMBH) * column 4, line 21 - column 5, line 24 * * figure 1 * ---	1,2,4,7, 10,12, 25-27,30	
A	EP 0 329 962 A (GKSS-FORSCHUNGSZENTRUM GEESTHACHT GMBH) -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 July 1997	Smolders, R

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