

Sept. 23, 1958

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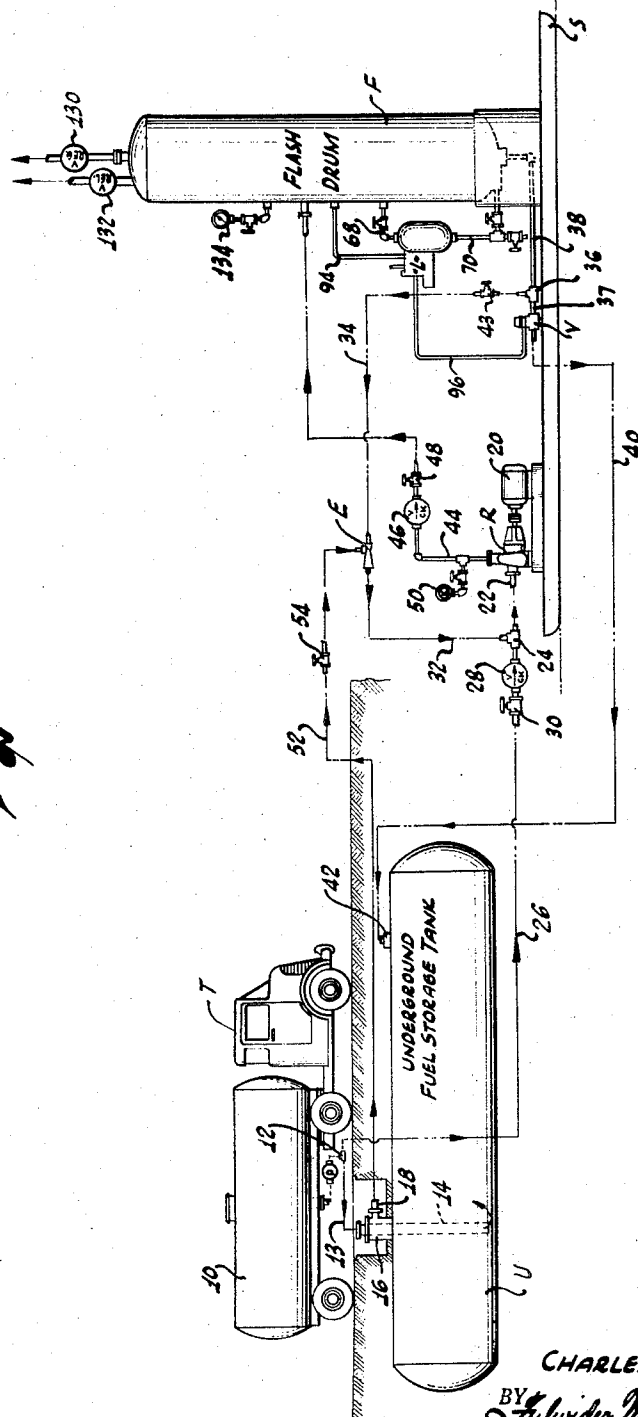
2,853,149

VAPOR RECOVERY APPARATUS

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3 Sheets-Sheet 1

Fig. 1



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3 Sheets-Sheet 2

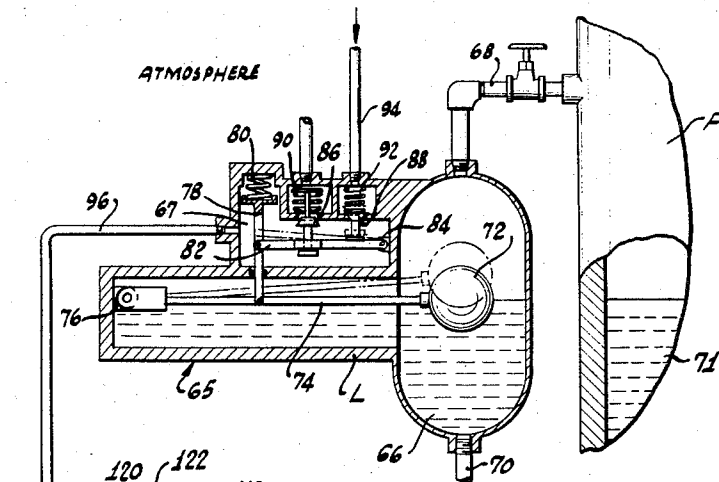


Fig. 2

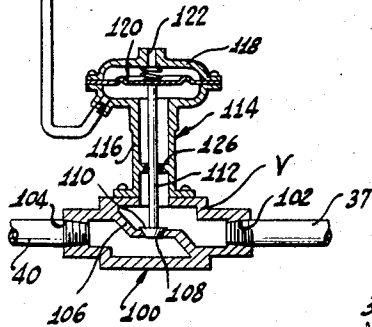


Fig. 3

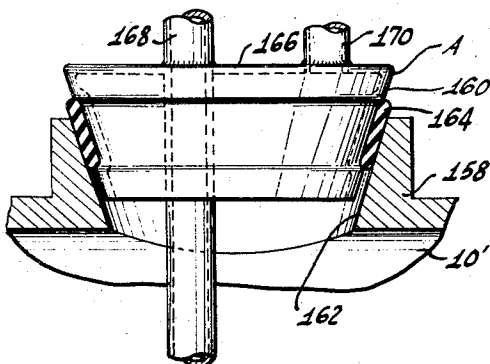
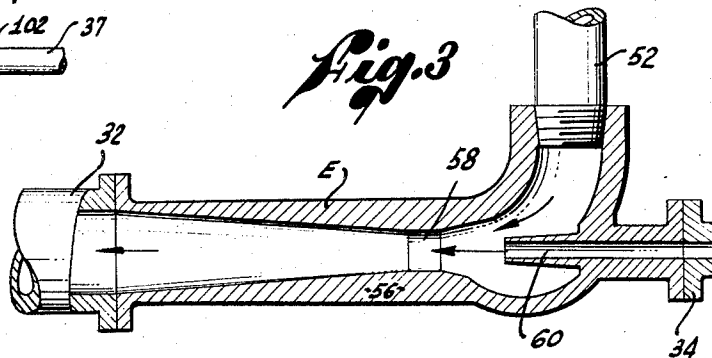


Fig. 5

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VAPOR RECOVERY APPARATUS

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4 Claims. (Cl. 183—2)

The present invention relates generally to vapor recovery systems and more particularly to a novel apparatus for recovering the hydrocarbon vapors that normally escape to the atmosphere during loading and unloading of gasoline transporting conveyances.

It has been determined that hydrocarbon losses to the atmosphere which take place when a tank truck or tank car is loaded at a bulk storage plant or unloaded at a retail service station contribute heavily to the air pollution problem now existing in and around the principal population centers of the country. The conventional tank truck and trailer combinations generally carry 6000 to 8000 gallons of gasoline and require from 15 to 30 minutes to load. Approximately 7 to 10 gallons of gasoline are lost in each loading, the exact amount being dependent upon the vapor pressure of the gasoline and the atmospheric temperature. A similar loss occurs from the storage tank of the retail service station when the truck is unloaded. In both instances the hydrocarbon vapors are mixed with the air displaced from the tank while the latter is being filled with gasoline. Although vapor recovery systems have been heretofore proposed to recover these hydrocarbon losses, the high cost of construction and operation of such systems has prevented their general acceptance.

It is a major object of the present invention to provide a novel and improved apparatus for recovering the volatile vapors escaping from a tank as it is filled with gasoline or the like.

Another object is to provide vapor recovery apparatus of the aforescribed nature which is comparatively inexpensive to manufacture, install and operate.

A further object of the invention is to provide a vapor recovery apparatus that is extremely efficient in operation.

Yet another object is to provide a vapor recovery apparatus of the aforescribed nature which is effective both when employed in conjunction with the loading of a tank truck or car at a bulk storage plant and when employed with the unloading thereof at a retail service station.

It is another object of the invention to provide vapor recovery apparatus of the aforescribed nature which is completely foolproof in operation and which requires minimum attention from its operator.

Yet another object of the invention is to provide vapor recovery apparatus that is compact in size and light in weight in order that it may find use in retail service stations wherein space is generally at a premium.

An additional object is to provide vapor recovery apparatus which is simple in design and rugged of construction whereby it may afford a long and trouble-free service life.

Another object is to provide apparatus for recovering vapors from a mixture of vapors and air by introducing such mixture into a liquid and then separating the air from the vapor-containing liquid. The method and apparatus of the present invention will substantially reduce

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contamination of the atmosphere with hydrocarbons when employed in conjunction with the loading or unloading of a gasoline carrying conveyance.

These and other objects and advantages of the present invention will become apparent from the following detailed description, when taken in conjunction with the appended drawings wherein:

Figure 1 is a partially diagrammatic side elevational view showing a preferred form of apparatus which may be employed in carrying out the method of the present invention, said method and apparatus being shown in conjunction with the unloading of a gasoline tank truck at a retail service station;

Figure 2 is an enlarged side elevational view taken partly in section and showing a liquid level control device utilized in said apparatus;

Figure 3 is an enlarged side elevation view taken in central vertical section showing an eductor member utilized with said apparatus;

Figure 4 is a partially diagrammatic side elevational view showing the apparatus being utilized in conjunction with the loading of a gasoline tank truck at a bulk storage plant; and

Figure 5 is an enlarged view taken partly in central vertical section showing an adaptor employed with the tank truck of Figure 4.

Referring to the drawings and particularly Figure 1 thereof, the preferred form of apparatus embodying the present invention is shown in conjunction with a gasoline tank truck T that is unloading gasoline into the underground storage tank U of a retail service station. The primary components of the apparatus are depicted as being mounted on the skid unit S in order to facilitate installation and maintenance. The tank truck T is provided with a conventional unloading pump P having its intake connected with the interior of the tank portion 10 of the truck and its outlet connected to a conventional T-fitting 12. One side of the T-fitting 12 is connected by a conduit 13 to the vertically extending input tube 14 of the storage tank U. This input tube 14 extends downwardly through the hollow nozzle 16 of the storage tank U to the lower portion of the latter. The nozzle 16 is sealed to the atmosphere and is provided at one side with an outlet pipe 18. As indicated by the directional arrows in Figure 1, as the level of the incoming gasoline rises within the storage tank U the gasoline vapors and air disposed above the liquid gasoline are forced upwardly out of the tank through the outlet pipe 18. The air enters the storage tank U by means of a conventional venting device (not shown) as the level of the gasoline falls due to withdrawals.

The skid unit S

The primary components mounted on the skid unit S include a pump R, an eductor E shown in detail in Figure 3, a flash tank F and a liquid level control mechanism L for the flash drum F. The liquid level control mechanism L is shown in detail in Figure 2. The pump R is preferably of the rotary sliding vane type and is driven by an electric motor 20.

The suction side of the pump R is connected by a short conduit 22 to one side of a T-fitting 24. The opposite side of the T-fitting 24 is connected by a conduit 26 to the side of the first-mentioned T-fitting 12 opposite the conduit 13. Preferably, a check valve 28 that opens towards the T-fitting 24 and a gate valve 30 are arranged in the conduit 26. The center of the T-fitting 24 is connected by a conduit 32 of the discharge side of the eductor E.

The input side of the eductor E is connected by a conduit 34 to the center portion of a T-fitting 36. One side

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of the T-fitting 36 is connected by a conduit 38 to the lower end of the flash drum F. The opposite side of this T-fitting 36 is connected by a short tubing 37 to a control valve V disclosed in detail in Figure 2 and described more fully hereinafter. The opposite side of the control valve V is connected by a conduit 40 to a return inlet fitting 42 formed in the upper portion of the storage tank U. A gate valve 43 is arranged in the conduit 40.

The discharge side of the pump R is connected by a conduit 44 to the intermediate portion of the flash drum F. Preferably, a check valve 46 and a gate valve 48 are arranged in the conduit 44. A pressure indicator 50 may also be disposed in this conduit. The intermediate portion of the eductor E is connected by a conduit 52 to the outlet pipe 18 of the storage tank U. A gate valve 54 is disposed in this conduit 52.

The eductor E

Referring particularly to Figure 3, the eductor E is of conventional construction and includes a body 56, the interior of which defines a venturi tube having a throat 58. A pressure nozzle 60 is formed at the inlet side of the eductor for receiving pressurized liquid from the conduit 34. The introduction of this pressurized liquid through the pressure nozzle 60 produces a high velocity jet through the throat 58 which lowers the pressure at this point so as to draw the gasoline vapors and air from the storage tank U through the conduit 52 into the confines of the eductor. This mixture of air and gasoline vapor is mixed with the liquid entering through the pressure nozzle 60 and forced out of the left-hand, or discharge, side of the eductor E into the conduit 32.

The liquid level control mechanism L

Referring now to Figures 1 and 2, the liquid level control mechanism L operates the control valve V so as to control the flow of liquid from the lower end of the flash drum F to the return fitting 42 of the storage tank U. The liquid level control mechanism L includes a housing 65 having a float chamber 66 in its lower portion and a valve chamber 67 in its upper portion. The upper end of the float chamber 66 is in communication with the intermediate portion of the flash drum F by piping 68 and its lower end is in communication with the lower end of the flash drum by means of piping 70. With this arrangement, the liquid level within the float chamber 66 will correspond exactly with the level of the liquid 71 within the flash drum F. A ball float 72 is disposed within the float chamber 66. This float 72 is affixed to the free end of a rod 74 having its opposite end pivotally secured to a bracket 76 formed at the side of the housing 65 opposite the float. The intermediate portion of the float rod 74 is pivotally secured to the lower end of an upstanding post 78. The upper end of this post 78 is constantly biased downwardly by a coil compression spring 80. The intermediate portion of the post 78 is pivotally affixed to a generally horizontal extending valve lever 82. The opposite end of this valve lever 82 is pivotally secured to the housing 65, as indicated at 34.

The intermediate portion of the valve lever 82 is connected to the stem of an exhaust valve 86 and the stem of a supply valve 88. The exhaust valve 86 is normally maintained open so as to connect the interior of the valve chamber 67 with the atmosphere. A coil compression spring 90 constantly biases the exhaust valve towards a closed position. The supply valve 88 is normally maintained in a closed position by a coil compression spring 92. The supply valve 88 is in communication with the interior of the flash drum F at a point above the level of the liquid 71 by a length of pipe 94. A second length of pipe 96 connects the interior of the valve chamber 67 with the control valve V.

In the operation of the liquid level control mechanism L, so long as the level of the liquid 71 within the flash drum F, and therefore within the float chamber 66, re-

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mains at the desired elevation, the float 72 and its connected parts will be disposed in their solid outline position of Figure 2. When, however, the liquid level rises above this elevation, the float 72 will be raised, as indicated by its dotted outline position in Figure 2. As the float 72 rises, the float rod 74 will also be raised so as to lift the post 78. This upward movement of the post 78 effects concurrent upward movement of the end of the valve lever 82 connected thereto. Such movement of the lever 82 serves to close the exhaust valve 86 and concurrently open the supply valve 88. The interior of the valve chamber 67 will in this manner be closed to the atmosphere, and concurrently placed in communication with the interior of the flash drum F.

The control valve V

The control valve V includes a valve body 100 formed at one end with a threaded opening 102 for receiving the conduit 37 and at its opposite end with a threaded opening 104 for receiving the conduit 40. As noted hereinabove, the conduit 37 is in communication with the lower end of the flash drum F, while the conduit 40 is in communication with the return fitting 42 of the storage tank U. A wall 106 divides the interior of the valve body 100. The mid-portion of this wall 106 is formed with a generally frusto-conical opening 108. This opening 108 serves as a seat for an upwardly-opening closure element 110. The closure element 110 is rigidly affixed to the lower end of an upstanding stem 112.

The diaphragm casing 114 is rigidly affixed to the upper end of the valve body 100. This diaphragm casing 114 is of hollow construction and includes a tubular lower portion 116 at the upper end of which is formed a hollow head 118 of enlarged diameter. A flexible metallic diaphragm 120 is disposed within this head 118. The portion of the head 118 above this diaphragm 120 is vented to the atmosphere by a vent 122. The portion of the head 118 below the diaphragm 120 is connected to the lower end of the pipe 96. The upper end of the stem 112 is affixed to the center of the diaphragm 120. A coil compression spring 124 is interposed between the upper surface of the diaphragm 120 and the interior of the head 118 so as to bias the stem 112 downwardly and thus maintain the valve element 110 seated within the opening 108. The interior of the diaphragm casing 114 is sealed from the interior of the valve body 100 by a conventional sealing ring 126.

The flash drum F

The flash drum F is essentially a hollow container that is designed to hold fluids existing at comparatively high pressures. In practice, this flash drum F has been designed to withstand pressures up to approximately 250 pounds per square inch. The upper portion of the flash drum F is formed with a back pressure control valve 130 which is designed to open when the pressure within the flash drum exceeds approximately 200 pounds per square inch. The upper portion of the flash drum F is also formed with a pressure relief valve 132 which is adapted to open at a pressure lower than that for which the flash drum F is designed but higher than that at which the back pressure control valve 130 will open. This pressure relief valve 132 will open under conditions of emergency such as fire or a failure of the back pressure control valve. A pressure indicator 134 is also shown mounted upon the upper portion of the flash drum F.

Operation of the apparatus shown in Figures 1, 2 and 3

In the operation of the aforescribed apparatus, the unloading pump P will transfer gasoline from the tank 10 of the truck T into the lower portion of the storage tank U. The introduction of this gasoline within the storage tank U will serve to displace the air above the level of the incoming liquid through the outlet 18. Mixed with this air will be hydrocarbon vapors which usually include a trace of propane, some butanes, pentanes, hexanes and

heavier compounds. The suction side of the pump R receives gasoline from the truck T through conduit 26 and from the lower end of the flash drum C by means of the conduits 32, 34 and 38. The eductor E is interposed between the conduits 32 and 34 and the flow of gasoline through this eductor serves to draw the mixture of air and hydrocarbon vapors from the upper portion of the storage tank U through the conduit 52 into the conduit 32. The resulting mixture is forced into the intermediate portion of the flash drum F by the pump R. During such passage the hydrocarbon vapors are dissolved or absorbed by the liquid gasoline. The liquid gasoline and air should be discharged into the flash drum F through conduit 44 at a pressure capable of maintaining the interior of the flash drum at approximately 200 pounds per square inch.

The liquid gasoline entering the flash drum F will fall to the lower portion thereof, the air and a small quantity of hydrocarbon vapors remaining above the level 71 of this liquid gasoline. As noted hereinabove, during operation of the pump R liquid gasoline from the conduit 26 constantly enters the flash drum F. The volume of this gasoline is increased by the hydrocarbon vapors recovered from the storage tank U and dissolved or absorbed in the liquid gasoline. The introduction of this liquid gasoline into the flash drum causes the liquid level 71 within the drum to rise. Referring now to Figure 2, upon such a rise in the liquid level 71 the float 72 closes the exhaust valve 86 and concurrently opens the supply valve 88. The valve chamber 67 will then be sealed to the atmosphere while pressurized fluid is admitted thereto from the upper portion of the flash drum. This pressurized fluid will be transferred to the lower portion of the control valve's head 118 so as to cause upward flexing of the diaphragm 120. In this manner the closure element 110 will be lifted off its seat 108 so as to allow liquid gasoline from the lower portion of the flash drum F to flow through conduits 37, 38 and 40 into the return fitting of the storage tank U. When enough liquid gasoline has been diverted to the storage tank U to lower the liquid level 71 to its desired elevation, the float 72 will return to its normal position thereby effecting concurrent closure of the supply valve 88 and opening of the exhaust valve 86.

It is important to note that the size of the flash drum F and the volume of liquid gasoline circulated by the pump R should be so designed that the temperature within the flash drum F remains below a maximum of 90 degrees Fahrenheit regardless of the temperature rise of the air and gasoline within the pump R. As the pressure within the flash drum exceeds the value required to open the back pressure control valve 130 the compressed air from the drum will be released to the atmosphere. At temperatures of approximately 90 degrees Fahrenheit the percentage of hydrocarbons saturated in this released air will be extremely low and will not cause excessive contamination of the atmosphere. Such hydrocarbons will constitute but a very small percentage of those displaced in the form of vapors from the storage tank U.

The remainder of these hydrocarbons from the storage tank U are recovered in the form of liquid gasoline and returned through conduits 37, 38 and 40 to the storage tank. It should be observed that by returning a portion of the liquid gasoline from the flash drum to the storage tank U, and by admitting fresh gasoline to the flash drum through conduit 26, the liquid gasoline in the flash drum is continuously replenished. In this manner excessive concentration of lighter hydrocarbon fractions is prevented. If such contamination was permitted the equilibrium within the flash drum would be adversely affected in that the lighter hydrocarbons would be released from the liquid gasoline and escape to the atmosphere with the air released through the back pressure control valve 130.

The apparatus of Figures 4 and 5

Referring now to Figure 4, the apparatus of the present invention is shown being operated in conjunction with

the loading of a gasoline tank truck T' at a bulk storage plant. The skid unit S' of Figure 4 is identical to that described hereinbefore in conjunction with the preceding figures, and the various components thereof bear primed reference numerals of these preceding figures.

The tank truck T' is shown alongside a conventional loading rack 150 having a filler pipe 152 connected to the discharge of a transfer pump TP. This pump TP is of conventional construction and may be of the centrifugal type. It is driven by an electric motor 154. The filler pipe 152 is provided with a control valve 156. The filler pipe 152 is connected to an annular adaptor A arranged in the hatch 158 of the tank 10' of truck T', and shown in detail in Figure 5.

Referring to Figure 5, the adaptor A is of hollow, generally frusto-conical construction having side walls 160 received by the opening 162 of the hatch 158. A resilient sealing ring 164 encircles the side walls 160 so as to provide a substantially vapor-tight seal between the adaptor A and the hatch 158. The upper ends of the side walls 160 are integrally affixed to a flat cover plate 166. A vertically extending inlet tube 168 is rigidly affixed as by welding to this cover plate 166. An outlet tube 170 is likewise rigidly affixed as by welding to the cover plate 166.

As indicated in Figure 4, the inlet tube 168 extends to the lower portion of the tank 10' when the adaptor A is in operative position. The upper end of the inlet tube 168 is connected to the filler pipe 152. The outlet tube 170 is connected to the conduit 52' connected to the eductor E'. The suction of the transfer pump TP is connected by a conduit 172 to fuel storage tanks S. In addition to being connected to the inlet tube 168, the discharge of the transfer pump TP is connected to the suction of the skid-mounted pump R' by conduit 26'.

The operation of this form of apparatus is substantially similar to that of the apparatus of Figures 1, 2 and 3. As liquid gasoline is pumped into the tank 10' of the truck T', the air and hydrocarbon vapors displaced therefrom are drawn by eductor E' into the conduit 32'. This mixture is forced into the flash drum F' by the sliding vane rotary pump R'. Separation of the air and liquid hydrocarbons takes place in the flash drum F' with the air being released to the atmosphere. Liquid gasoline is returned to the storage tanks S whenever the liquid level within the flash drum rises above the desired elevation by means of the liquid level control mechanism L' and the control valve V'.

From the foregoing description it will be apparent that the apparatus of the present invention will effectively recover the hydrocarbons that normally escape to the atmosphere during loading and unloading of gasoline transporting conveyances. The utilization of such apparatus will therefore eliminate an important air pollution problem. Additionally, the utilization of this method and apparatus will conserve gasoline which is presently being wasted. It should be particularly noted that various forms of liquid level control mechanisms, eductors and pumps may be employed in place of those specifically described hereinbefore. It should likewise be noted that means for cooling the flash drum may be provided if necessary in order to maintain the temperature of its interior at the proper value.

Various other modifications and changes may be made with respect to the foregoing description without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. Apparatus for recovering the vapors displaced from a vented tank when it is filled with a liquid from a second tank, said vented tank having an outlet in its upper portion, comprising: a flash drum; pump means; a conduit interconnecting the lower end of said flash drum and the suction of said pump means; an eductor arranged in said conduit; fluid-transfer means connecting

said outlet and said eductor; a second conduit effecting communication between said second tank and the suction of said pump; a third conduit interconnecting the discharge of said pump means and said flash drum; an additional conduit connecting the lower portion of said flash drum and said vented tank; and means for withdrawing said air from the upper portion of said flash drum.

2. Apparatus for recovering the vapors displaced from a vented tank when it is filled with a liquid from a second tank, said vented tank having an outlet in its upper portion, comprising: a flash drum; pump means; a conduit interconnecting the lower end of said flash drum and the suction of said pump means; an eductor arranged in said conduit; fluid-transfer means connecting said outlet and said eductor; a second conduit effecting communication between said second tank and the suction of said pump; a third conduit interconnecting the discharge of said pump means and a point on said flash drum above its lower end; a control valve in communication with the lower end of said flash drum, said control valve normally being closed; a liquid level control mechanism operatively connected to said flash drum and said control valve for opening said control valve when the liquid level within said flash drum rises above a predetermined elevation lower than said point; an additional conduit connecting said control valve and said vented tank; and means for withdrawing said air from the upper portion of said flash drum.

3. Apparatus for recovering hydrocarbon vapors from a tank when it is filled with gasoline from a second tank, comprising: a flash drum having its interior pressurized; pump means having an intake and discharge in communication with said flash drum and serving to pressurize said flash drum; conduit means interconnecting said outlet and said pump means whereby the mixture of air and hydrocarbon vapors displaced from said tank will be urged into said flash drum by said pump means, said vapors being absorbed by said gasoline in said conduit means before said mixture reaches said flash drum;

second conduit means effecting communication between said second tank and said flash drum; and a constant pressure outlet valve on the upper portion of said flash drum for venting said air when the pressure within said drum exceeds approximately 200 pounds per square inch.

4. Apparatus for recovering the air and vapors displaced from a vented tank when it is filled with gasoline from a second tank, said vented tank having an outlet in its upper portion, comprising: a flash drum; pump means; a conduit interconnecting the lower end of said flash drum and the suction of said pump means; fluid-transfer means connected to said outlet for conducting said air and vapors; means interposed between said conduit and said fluid-transfer means to intimately mix said air and vapors from said fluid-transfer means with gasoline flowing through said conduit and thereby effect the absorption of said vapors into the gasoline flowing through said conduit; a second conduit effecting communication between said second tank and the suction of said pump; a third conduit interconnecting the discharge of said pump means and a point on said flash drum above its lower end; a control valve in communication with the lower end of said flash drum, said control valve normally being closed; a liquid level control mechanism operatively connected to said flash drum and said control valve for opening said control valve when the gasoline level within said flash drum rises above a predetermined elevation lower than said point; a return conduit connecting said control valve and said vented tank; and means for withdrawing said air from the upper portion of said flash drum.

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