Aug. 9, 1960 S. S. SMITH 2,948,294

STORAGE ARRANGEMENT FOR HIGHLY VOLATILE LIQUIDS

Filed Feb. 21, 1956 3 Sheets-Sheet 1

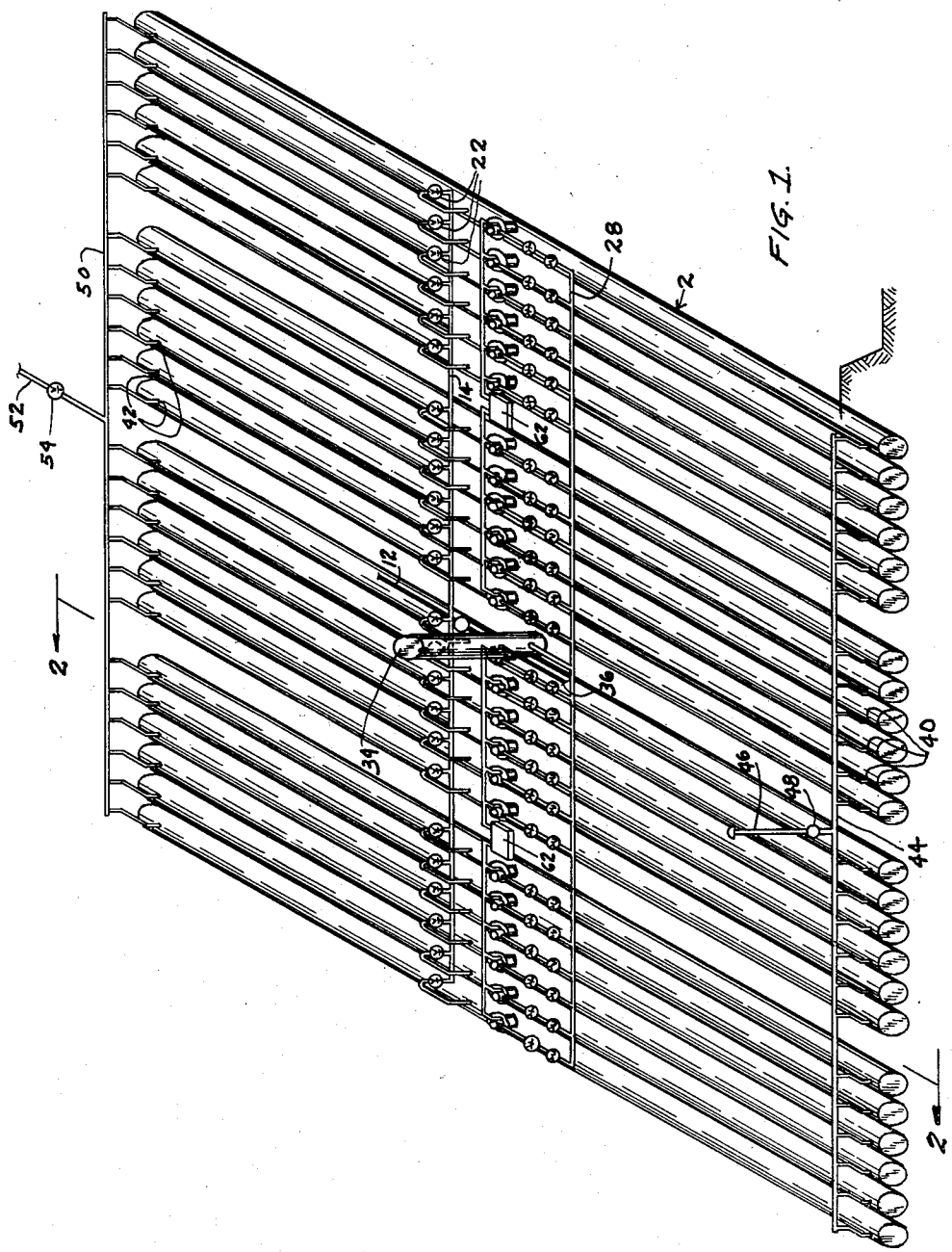


FIG. 1.

INVENTOR.
Sydney S. Smith

BY
Neil J. Driscoll
ATTY.

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Filed Feb. 21, 1956 3 Sheets-Sheet 2

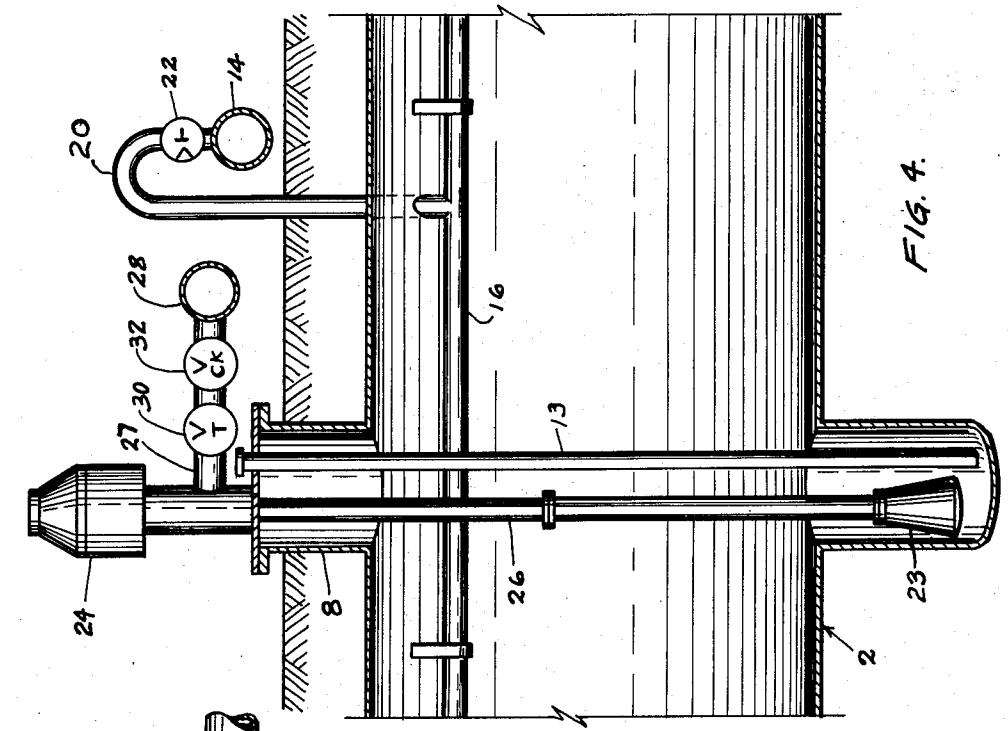


FIG. 4.

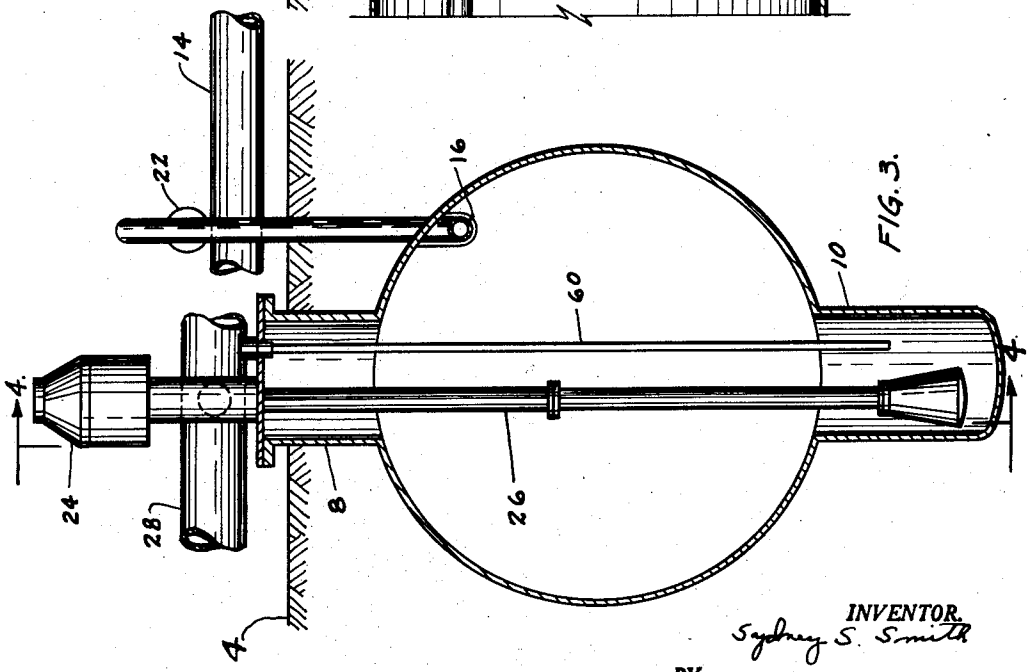


FIG. 3.

INVENTOR.
Sydney S. Smith

BY
Neil J. Driscoll
ATTY.

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Filed Feb. 21, 1956 3 Sheets-Sheet 3

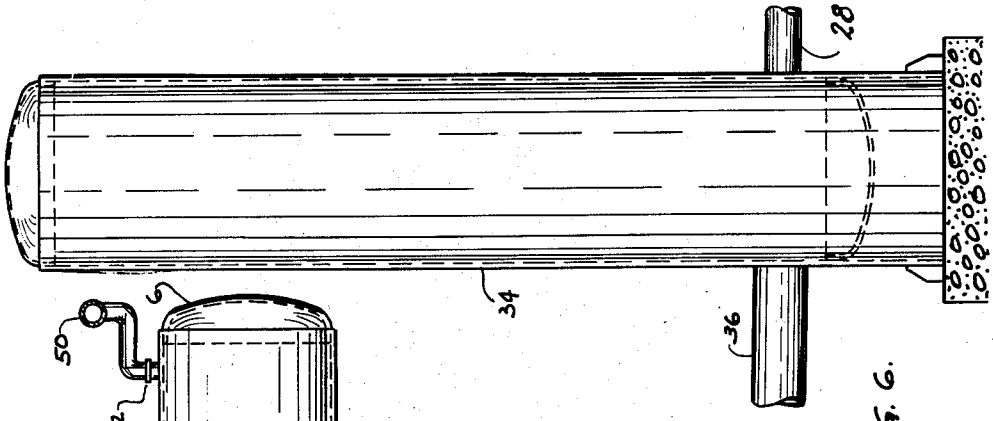


FIG. 6.

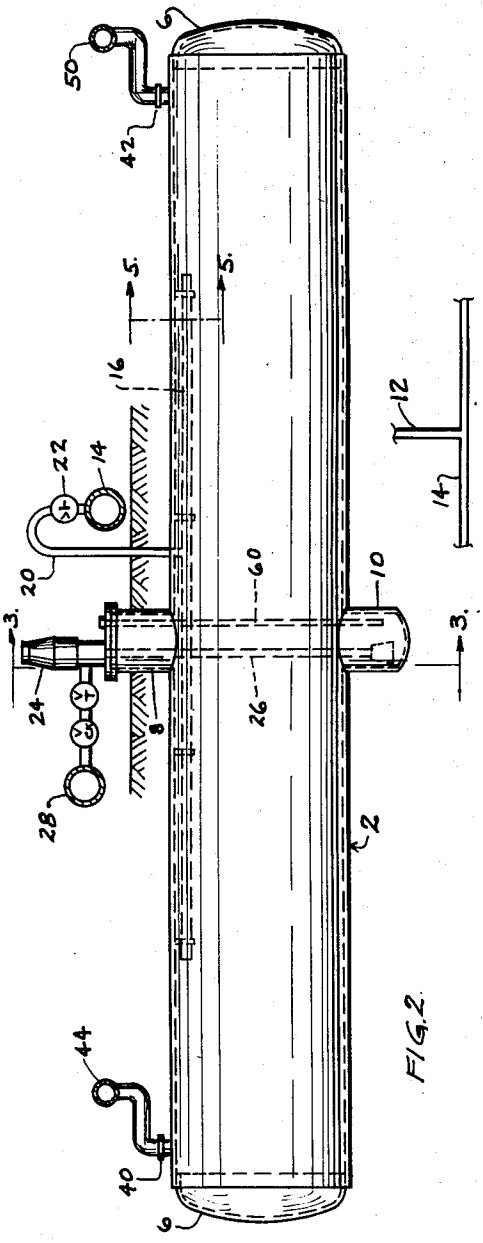


FIG. 2.

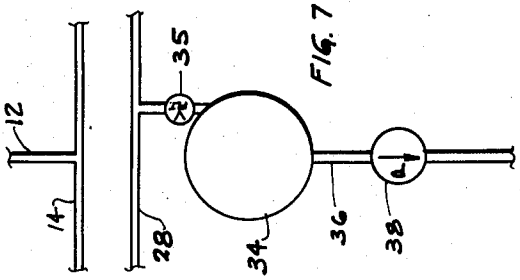


FIG. 7

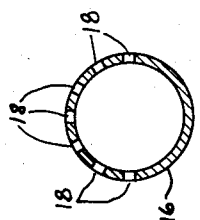


FIG. 5.

INVENTOR.
Sydney S. Smith

BY
Neil J. Driscoll
ATTY.

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STORAGE ARRANGEMENT FOR HIGHLY VOLATILE LIQUIDS

Sydney S. Smith, Scarsdale, N.Y., assignor, by mesne assignments, to Union Tank Car Company, Chicago, Ill., a corporation of New Jersey

Filed Feb. 21, 1956, Ser. No. 566,813

1 Claim. (Cl. 137—263)

The invention relates to an arrangement adapted to receive and store highly volatile liquids such as liquefied petroleum and the like.

The use of liquefied petroleum has rapidly grown in recent years. Particularly, the increased acceptance of liquefied petroleum by users in large urban markets has increased the demand, said users having heretofore avoided such use because of certain dangerous characteristics of the product. To satisfy this increased demand, ways to increase the volume of product transported from the source of the raw material to the remote large consumer areas are being explored. Usually, liquefied petroleum is transported in tank cars, trucks, barges, or the like. It has long been obvious to many persons familiar with the industry, that such methods of transport did not lend themselves to quick volume distribution and reduced costs. Accordingly, cross-country pipe lines have been and are being utilized to provide the high rate and volume transport of these products. As a result of this means of transport, many problems have arisen and the industry has long felt the need for a storage arrangement which would satisfy these problems and aid in rendering the pipe line method of transport economical.

The problems mentioned revolve generally around the nature of liquefied petroleum product and the resulting difficulties in handling. Considering, for example, the liquefied petroleum product known as propane, it is well known that it will boil and evaporate at normal temperatures and pressures which makes it difficult to move in the liquid state. The use of the pipe line method of transportation requires that the product be moved under pressure and at high rates per unit of time. These factors make the reception of the product, both at way stations along the pipe line route and receiving depots, an extremely difficult and costly problem. Storage facilities of flexible nature must be provided. That is, the facilities must have the capacity to receive and store the liquid under pressure at high pipe line rates, and additionally said facilities must have the capacity to eject the stored liquid into pipe line at similarly high rates under pressure. Further, the storage facilities, to render them commercially feasible, must also be easily adaptable to slow reception and ejection of the liquid. It is therefore seen that the storage facility must lend itself to any combination of slow and fast reception and ejection of product as the requirements of a particular installation may demand.

Further problems are also presented because of the fact that liquids of this nature must be kept under pressure. The facilities designed reflect this fact and must also take into account the effect of climatic temperature change on the stored products. For example, normal heating resulting from action of the sun considerably increases the pressures within the storing tanks. It is also well known that products of this kind have certain dangerous characteristics, such as high volatility which in turn results in inherent fire and explosion hazards. Therefore,

fire protection is an important consideration in the design of any storage facilities for this type of product.

With the above in mind, it has been found that the initial construction expense and up keep costs of storage stations heretofore used for products of this type, has adversely affected transport of this type product in pipe lines and the industry has long been searching for economical ways to reduce these costs and aid in making the pipe line method of transport commercially attractive.

Accordingly, it is a primary object of this invention to provide an arrangement particularly adapted to the reception, storage and ejection of liquefied petroleum products and the like, that is both economical in construction and upkeep costs and sufficiently flexible to accommodate the various requirements of present day product distribution methods. Particularly, the invention comprehends, in general, a storage arrangement having a plurality of main storage compartments located underground and comprising a plurality of separate tanks novelty and commonly manifolded so as to accommodate high and low rate product acceptance and discharge in combination with an ejection standpipe or pressure tank and protective venting, the latter protecting the arrangement against excessive high vapor pressure as well as liquid overflow.

It has been found that the arrangement herein disclosed is extremely economical from the standpoint of initial cost and further is sufficiently flexible to meet the requirements of input stations, way stations, or final depots. Additionally, the system offers adequate protective features from the standpoint of corrosion, fire and explosion.

It will also be understood that the arrangement disclosed is particularly advantageous to certain industrial users in that it will afford him flexibility from the standpoint of types of products storable. That is, the user, if he so desires, can use certain tanks in the battery to store one type of product and use others to store entirely different type of products and can thereafter selectibly discharge from the desired tanks and avoid any possibility of intermixing.

These and other objects of the invention will be more clearly understood from an examination of the following specification and the associated drawings, wherein:

Figure 1 is a perspective, partially schematic view showing a storage arrangement embodying the invention,

Figure 2 is a side elevational, partially schematic view of a typical tank employed in Figure 1,

Figure 3 is a sectional view, partially in elevation, taken approximately along line 3—3 of Figure 2,

Figure 4 is a sectional view, partially in elevation, taken approximately along line 4—4 of Figure 3,

Figure 5 is a detail view of the tank fill line taken along line 5—5 of Figure 2,

Figure 6 is a detail view of the standpipe employed in the invention, and

Figure 7 is a schematic view of the piping arrangement associated with the standpipe.

Describing the invention in detail and directing attention to Figures 1 and 2, it will be seen that the storage arrangement comprises a plurality of cylindrical, elongated tanks, indicated generally at 2. The tanks 2 are preferably located underground, that is, the major portions thereof are covered with earth fill, such as is illustrated at 4 in Figure 3. In view of the ease of shop fabrication, each tank 2 is preferably cylindrical in cross-section and is provided with dished heads 6, 6 at the opposite ends thereof. Additionally, the tanks 2 may be constructed of slightly different diameters, whereby pairs of tanks may be telescoped one within the the other to reduce shipping costs from the point of shop fabrication to the point of field construction.

Centrally of each tank 2, a manway 8 is provided, said manway extending to a point immediately above the surface of the fill 4. A sump 10 is positioned on each tank 2 centrally thereof and at a point immediately below the manway 8. It will be understood that the tank 2 is provided with a slight downward taper from the ends 6, 6 to the sump 10, whereby liquid in the tank will normally be urged by gravity to flow toward the sump 10. It is desirable and necessary that the product, when delivered to the consumer, be dry. The product, when deposited in the storage system may be and frequently is contaminated with water, such as, for example, salt water incident to salt dome storage at the producing site. Occasionally water from the pipe line itself, which is incident to and a result of the use of the pipe line to ship products of varying kind, will also find its way to the storage tanks. This water, being heavier than the liquefied petroleum product will move to the bottom of the tank whereat the central taper feature will carry it to the bottom of the sump 10 for removal. To accommodate such removal, there is provided a closable water drain line 13 which extends downwardly into each sump 10 to the bottom thereof at a point substantially below the pump 23. At determined intervals, the station operator may sample each tank 2 for the presence of water, and, if such water is found in any tank, it could be removed via line 13.

A main line 12, which may be connected (not shown) to a cross-country pipe line, is arranged to communicate with a common fill header 14, said fill header 14 extending transversely of the long axis of the tanks 2. Each tank 2 has a fill line 16 internally thereof and arranged to extend in a generally parallel relationship to the long axis of said tank and adjacent the upper limit thereof. The fill line 16 may be provided with a plurality of discharge apertures 18 formed in the circumference thereof, as is best shown in Figure 5. It will be understood that the apertures 18 are preferably distributed along the entire length of the line 16. This arrangement assures an even distribution of incoming product to various sections of the tank and in effect sprays the incoming product over a large area in the tank. This important feature of spraying the incoming fluid results in a stabilization of pressure at the vapor pressure of the product in the tank in view of the fact that a large portion of the vapor in the tank is absorbed and returned to product as the volume of the tank becomes filled with liquid. Thereafter the pressure within the tank remains constant regardless of the amount of product in the tank. Therefore, the amount of product in vapor form that may be vented to atmosphere during filling is eliminated, except in the rare event that the vapor pressure of the liquid at the temperature received in the tanks exceeds the pressure setting of the relief valve of the system, a contingency that can be controlled.

Each fill line 16 communicates with an incoming pipe 20 which in turn communicates with the common fill header 14. It will be noted that each line 20 has provided therein a gate valve 22 to selectively open or close communication between the header 14 and the related fill line 16.

A discharge pump 23 is preferably located in the sump 10 whereby its suction side will be constantly flooded with product. A pump discharge line 26 extends upwardly from the sump 10 and encloses a drive shaft from the pump motor 24, as is best seen in Figures 3 and 4. The discharge side of the pump 23 communicates with the line 27 which in turn communicates with a common discharge header 28. It will be particularly noted that each tank 2 is provided with an individual pump 23, said pumps 23 discharging to the common header 28. Each line 27 may be provided with a gate valve 30 as well as a one way check valve 32, the latter accommodating flow to the discharge header 28 only.

A vertical pressure tank 34 is preferably located at a point centrally of the battery of tanks 2, said tank 34 communicating with the common discharge header 28 and arranged to receive the product therefrom. A float controlled valve 35 is in the line between the discharge header 28 and the tank 34 to close communication therebetween in the event that the tank becomes full. A pump out line 36 communicates with the lower end of the tank 34 and the suction side of a variable capacity pump 38. The discharge side of the pump 38 may then be connected (not shown) with a pump out line which may be selectably connectable to a pipe line or other distribution facilities.

Returning to Figures 1 and 2, it will be seen that each tank 2 is provided with ports 40, and 42 adjacent the opposite ends thereof. Considering the ports 40, it will be noted that they communicate with a common header 44, said header 44 communicating with a line 46 which may be open to the atmosphere. The line 46 has a conventional rupture valve 48 located therein. This particular structure is desirable in the event that one of the tanks becomes filled with product without manual or automatic shut off operation (hereinafter described). It will be noted that any liquid overflow is accommodated by the header 44 and that the liquid will be carried to other tanks 2 in the battery that have not been filled. In the event that the entire battery of the tanks 2 are filled to capacity and a particular shut off fails to operate, the valve 48 may be arranged to rupture under appropriate liquid pressure and accommodate escape of the liquid through the line 46 which may carry the liquid to a safe disposal area.

Considering the other end of the tanks 2, it will be noted that the ports 42 on each tank are also arranged to communicate with a common header 50, said common header 50 is connected with a line 52 which may extend to an appropriate flare stack (not shown) or the like. A relief valve 54 may be located in the line 52 and arranged to open under the action of a predetermined vapor pressure. Thus, if for some reason, the vapor pressure in the battery of tanks 2 should rise to an unsafe level the valve 54 will open and accommodate the escape of said pressure at some point where it can be safely burned off.

Directing attention to Figures 2 and 3, it will be seen that a liquid level indicator and control line 60 is arranged to extend downwardly from the top of the manway 8 into the sump 10 immediately adjacent the pump line 26. The liquid level arrangement (not shown in detail) may be of any conventional variety employed by those skilled in the art to determine the level of the liquid in a particular tank. For example, a conventional electronic level indicator may be employed, said indicator translating the level information in a particular tank to a plurality of dials (not shown) which may be located at a central control station 62 (Figure 1). In the alternative, a conventional float type indicator (not shown) may also be used to furnish the same information.

In normal operation of the arrangement, it is desirable on initial filling, to clear each tank 2 of air therein. This may be accomplished by opening lines 52 and 46 upon initial entrance of the propane into the tank. Thus, it will be understood that the fluid is delivered through pipe 12 to the header 14 and distributed from the header 14 concurrently to each lead line 20, from whence it is conducted to the fill line 16, whereat it is sprayed internally throughout each tank. The liquid, being vaporized at normal pressure, will immediately set up a vapor pressure within the tank. Because the opposed ends 6 of the tank are at a higher level than the central portion thereof, the air will be urged by the vapor in the tank and escape through the ports 40, 42 and the lines 46 and 52. After initial air purging, the lines 52 and 48 may be closed and it can be safely assumed that all of the air in the tank has been eliminated and the non-liquid occupying space

therein will thereafter be filled entirely by the product in the vapor phase. Thereafter upon entrance or exit of product in the tank, the pressure in the tank will remain virtually constant at just about the vapor pressure of the liquid regardless of the quantity of liquid in a given tank.

It will also be understood that the particular arrangement of the fill line **12** and manifold **14** communicating in parallel with the battery of tanks **2**, will be such as will accommodate a high entrance rate of product, that is, the arrangement will accommodate the high product rates normally found in pipe line transportation. As each tank becomes full, the associated valve **22** may be manually or automatically shut off until the entire battery of tanks **2** is completely full of product. At this point product entrance through line **12** is halted. When it is desired to empty the tanks, and particularly where it is desired to return the product to a pipe line having product therein moving at a high pipe line rate, it is necessary to open the valves **30** and start the pumps **23**, whereby each tank discharges into the discharge header **28**, which in turn carries the product to and fills the vertical pressure tank **34**. The tank **34** is necessary to assure that the suction side of the pump **38**, which discharges the product to the pipe line, will be constantly flooded with product. As each tank approaches a predetermined empty condition, the related pump is shut off leaving the tank in condition to again receive and store product.

The particular arrangement of the individual pumps **23** and common header **28** and the tank **34** will enable the product stored in the tanks **2** to be discharged to the pipe line under proper pressure and at product rates complementing the high pipe line rates. Thus, it will be understood that the arrangement described is peculiarly adaptable to the storage and retransmission of highly volatile liquids which are transported cross-country in pipe lines. Additionally, the tanks **2** may receive product even though it is transmitted through pipe **12** at relatively low rates, as may be found where product is transported by barge or railway car. Further, because each tank is equipped with an individual pump **23** that can be operated independently, discharge to line **36** can be handled at relatively low rates. Additionally, individual tanks in the battery can be separately discharged.

Thus, it will be seen that the disclosed storage arrangement is readily adaptable to and solves the problems incident to the low cost transportation of highly volatile liquids from producing areas to consuming areas. It will further be understood that because of the underground disposition of the tanks, the tanks **2** may be designed with considerably thinner wall sections, and still withstand vapor pressure of the contained liquid. Further, the underground disposition of the tanks substantially shields the tanks from climatic action and temperature change which may result in extremely high vapor pressures due to excessive heating. In addition, the fire hazard associated with this arrangement is considerably reduced because a leak in a tank cannot be supplied with oxygen needed to support fire until the product makes its way to the soil surface whereat it may burn without transmitting an unreasonable amount of heat back to the tanks.

Those familiar with the art will additionally appreciate the feature that all tank connections, manifolds, headers and the like are located above ground (Figures 1, 3 and 4) while the main storage tanks are below ground. This avoids the possibility of underground leakage which may result from tank and/or foundation settling with attendant unknown product loss. Further, if a leak or some other accident should affect a tank or its associated connection that tank can readily be isolated and product thereafter can be received into or ejected from the remaining tanks in the battery. The individual controllable output pump on each tank is one of the features responsible for this desirable arrangement.

It will be understood that the invention as shown is by way of illustration and not limitation and that it may be subject to various modifications without departing from the spirit thereof or the scope of the appended claim.

What is claimed is:

In a receiving, storage and dispensing arrangement for volatile liquid, the combination of a plurality of separate elongated product tanks disposed underground, a pump associated with each tank and including an inlet means communicating with the bottom of said tank, said tank being in graded relationship to said pump inlet means to accommodate gravity liquid flow to its pump inlet means, an intake manifold having a connection to a product source, a first line communicating with each tank and each line having a connection to the manifold, each line having independently operated stop valve means, a discharge header, a second line communicating with each tank at its pump outlet means and each having a connection to the discharge header, each of said pumps being operative to deliver liquid from its tank to the header under pressure, a check valve in each of said second lines accommodating flow from the tank to the header only, other independently operated stop valve means in each of the second lines, a pressure tank above the ground, a first conduit establishing communication between the discharge header and the pressure tank, control valve means in the first conduit to selectively close said last mentioned communication, a second conduit having a connection to the pressure tank, variable capacity pump means operatively associated with the second conduit to evacuate product from the pressure tank at selectible varying rates, and pressure relief means including a second header in communication with each of the underground tanks, a third conduit communicating with said second header and extending above the ground, and means operable in response to a predetermined pressure in the third conduit for venting said tanks.

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