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EQUIPMENT FOR STORING VOLATILE LIQUIDS.

Filed Oct. 31, 1938

2 Sheets-Sheet 1

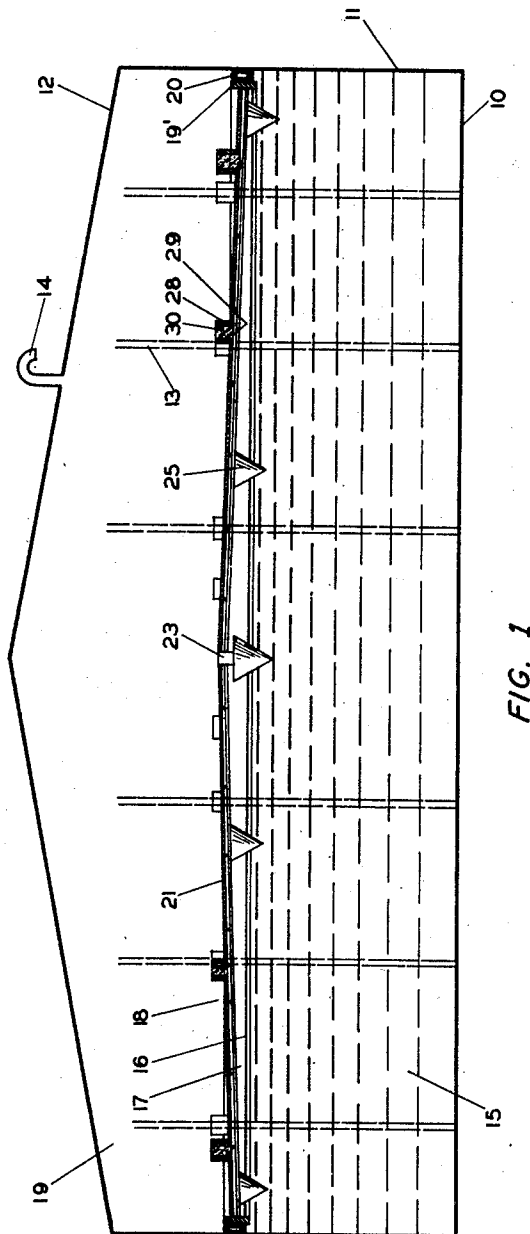


FIG. 1

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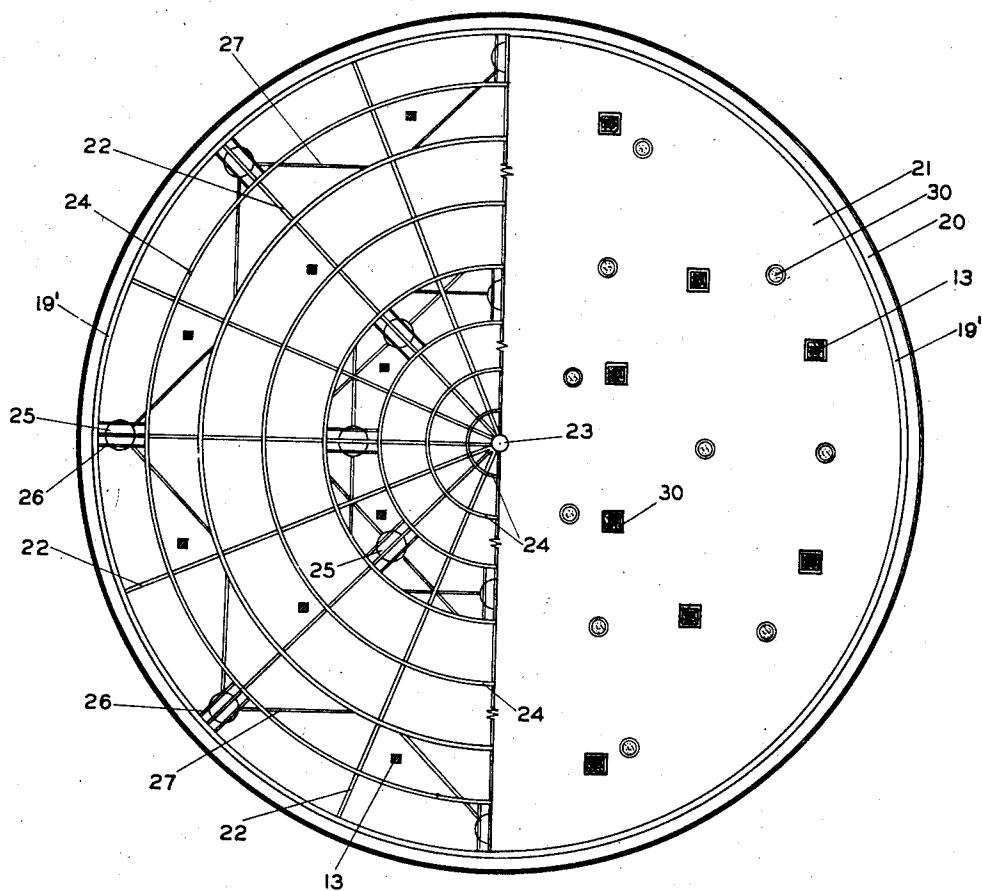


FIG. 2

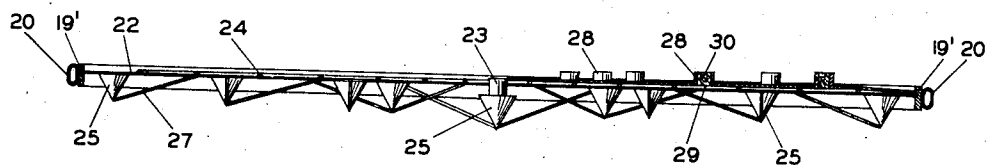


FIG. 3

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UNITED STATES PATENT OFFICE

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EQUIPMENT FOR STORING VOLATILE LIQUIDS

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3 Claims. (Cl. 220—26)

This invention relates to equipment for minimizing evaporation losses in the storage of volatile liquids in large tanks or reservoirs.

The present invention is confined to that class of liquids whose vapor pressure at maximum storage temperature is not greater than the atmospheric pressure at a particular locality. While this invention primarily contemplates the minimizing of the evaporation losses heretofore incurred in the storage of petroleum and petroleum products ranging in vapor pressure from crude oil to 12-pound natural gasoline, it is also applicable to the storage of many other volatile liquids, including alcohols, esters, ethers, ketones and the like, whose vapor pressures are similar to or lower than that of 12-pound natural gasoline. At low storage temperatures even natural gasoline of 26-pound Reid vapor pressure would come within this classification since the controlling factor is that the vapor pressure of the liquid at maximum storage temperature shall not exceed one atmosphere.

The losses of the more volatile components of petroleum liquids stored in large tanks is occasioned almost entirely by the "breathing" action of the contents of the storage tanks. This is due partially to the expelling of air laden with petroleum vapor when the tanks are being filled. Also, after the petroleum has been introduced into the tanks, large volumes of vapor laden air are expelled due to the evaporation of the petroleum and expansion of the air in the upper portion of the tanks caused by a rise in temperature or by a decrease in barometric pressure.

A number of methods have been devised to reduce these losses. The better known methods include the following: (a) spraying the roofs of storage tanks with water; (b) equipping storage tanks with floating roofs or decks; (c) installing diaphragm roofs on storage tanks; and (d) providing storage tanks with breather bags. While all of these methods are correct in principle to a greater or lesser degree, none have proven fully satisfactory, as they are either inherently inefficient or too expensive to construct and maintain. The result is that these various methods have not been accepted by the petroleum industry and their application has been limited to isolated cases of great severity.

The practice of my instant invention eliminates practically all of the difficulties experienced in the past in reducing evaporation losses. It utilizes the well known principle that evaporation of a volatile liquid entirely ceases when the

gas or vapor phase in contact with the liquid is in equilibrium. Based on the true scientific purpose of my invention, the contents of a storage tank so equipped may be said to consist of four phases. The phases concerned, beginning at the bottom of the tank and progressing upwardly therefrom, are as follows:

I. A liquid phase, which consists of the volatile liquid being stored.

II. A continuous vapor phase, one or more inches in thickness, in equilibrium with the liquid phase. This vapor phase consists of the vapor of the liquid being stored.

III. A solid phase to retain the vapor phase in position but so constructed and arranged as not to control the pressure of the vapor phase.

IV. A gas phase, composed almost entirely of air, out of equilibrium with the liquid phase.

The thin equilibrium vapor phase referred to above is the most essential part of this invention, and the thinner it is, within limits, the more effective it will be, for small volume brings it more perfectly into equilibrium. Consequently, there will be less movement by expansion or contraction due to temperature changes. It is evident that the volume of the vapor phase is dependent on the design and construction of the solid phase which is above it and retains it in position. Full details of the construction of the solid phase as well as a complete description of the relationship of the liquid, vapor, solid, and gas phases will be presented further along in this specification. It is sufficient to point out at this time that this invention performs all of the necessary functions of minimizing evaporation losses in an eminently satisfactory manner.

The primary object of this invention is to provide equipment whereby the evaporation losses of volatile liquids stored in large tanks are substantially eliminated.

Another object of this invention is to provide equipment for minimizing the evaporation losses of large volumes of stored volatile liquids, this equipment being reasonable in first cost and inexpensive to install and maintain.

These and additional objects and advantages will be readily apparent from the following description and annexed drawings, wherein,

Figure 1 is a vertical cross section view through a storage tank illustrating a preferred embodiment of my invention,

Figure 2 is a plan view with part of the cover removed, showing a typical form of solid phase, and

Figure 3 is a detailed vertical view of the solid phase illustrated in Figure 2.

Referring to the drawings, there is illustrated in Figure 1, a conventional type of storage tank consisting of a bottom wall 10, a vertical cylindrical side wall 11, and a roof 12, which is supported by posts 13. A vent or breather pipe 14 of the usual type establishes communication between the interior of the tank and the atmosphere. In the lower portion of the storage tank is a volatile liquid 15, such as crude petroleum, having a liquid level 16. This is the liquid phase mentioned above while reference numerals 17, 18, and 19 indicate the above mentioned vapor phase, solid phase, and gas phase, respectively.

Solid phase 18 is a diaphragm built upon an annular metal ring 19', whose external diameter approximates the internal diameter of the tank. The space between ring 19' and the side wall of the tank is preferably sealed off by means of a flexible bumper or tube 20. A fabric cover 21 which has been impregnated with a suitable synthetic resin is lightly stretched across the upper end of ring 19'. The fabric is coated on either or both surfaces with a metal foil, such as aluminum foil, to render it impervious to vapor diffusion as well as to cooperate with the resin to protect the fabric against humidity changes. Any suitable grade of paper or other material may be used, in place of the fabric, if desired. Whether a fabric, paper, or other material is used for the cover, it is manufactured in strips and then joined by sewing, cementing or both into a circular sheet of proper size.

When solid phase 18 is in place in the tank, it is supported in position by a normally floating pontoon structure. A series of flexible metal spokes 22 extend radially from a hub 23 in the center of the plane of ring 19' to said ring proper. Attached to these spokes, preferably by spot welding, are a number of metal wires 24 which are concentric with respect to both hub 23 and ring 19'. This arrangement of spokes 22 and wires 24 forms a network to which pontoons or buoys 25 are securely fastened by means of supports 26 and guides 27. The buoys are hollow tapered bodies, filled with air, and are constructed of a suitable material such as paper which is properly impregnated with an insoluble plastic. For the purposes of this invention, the buoys may be made into any one of a variety of shapes. For example, they may be prismatic, pyramidal or conical bodies, the latter being the type of hollow body illustrated in the drawings. By placing the buoys with their apexes down and their bases up, I am able to readily compensate for any variation in the density of the liquid in which they float. It will be evident from an inspection of Figure 2 that by providing a greater concentration of pontoons near the center of the wire network, an excess of buoyancy is obtained at the center of the structure. This results in the solid phase as a whole being slightly convex upwardly. It is intended that the cubic content of the space between the solid phase and the liquid phase on which it floats shall be a reasonable minimum to retain a vapor phase which is thicker at the center than at the edges.

The metal framework supports cover 21 in a position just above liquid level 16 when the cover is completely deflated. The cover is purposely flexible to permit it to inflate and deflate, so as to compensate for condensation, contraction, and expansion of the vapor phase. This rising and

falling of the diaphragm cover need only be one or two inches for the satisfactory operation of my invention.

It is not desirable that the solid phase shall be gas tight as to pressure. Therefore, to ensure that it is not and to maintain its static pressure in equilibrium with the gas phase directly above it, a plurality of hydrostatic pressure tubes 28 are provided. These tubes, through apertures 29 in the cover, place the vapor phase and the gas phase in communication with each other. The tubes are of a sufficient height so that the hydrostatic head of a column of the vapor phase of that height will be equal in pounds per square foot to the weight of the impervious material of the solid phase. Otherwise, the diaphragm would never inflate. A porous substance, such as glass wool 30, is loosely packed into each tube. The tubes may be located at the openings in the diaphragm for posts 13 and necessary additional tubes may be provided as shown in the drawings. It is evident that the tubes near the side wall of the tank must be longer by an amount equal to the convexity of the inflated diaphragm in order to prevent overflow through these tubes. My intention is not to completely eliminate diffusion, but rather to retard the same. By virtue of the small volume of the vapor space intermediate the diaphragm and the liquid, the breathing loss through the tubes is negligible.

It is to be understood that the form of this invention, herewith shown and described, is to be taken as a preferred example of the same and that various changes in size, shape and arrangement of parts may be resorted to without departing from the spirit of this invention, and further that the theories of operation set out, although believed to be accurate, are not to be considered as the sole basis of the operativeness of this device, but that this device does operate successfully whether or not upon the principles described herein, this invention to be limited only by the appended claims.

I claim:

1. A floatable diaphragm for use in a storage tank to minimize the evaporation losses of volatile liquids contained therein, comprising a rigid ring, means attached to the ring for sealing the space between the ring and the inner surface of the side wall of the tank, an impervious flexible cover lightly stretched across the ring, apertures in the cover, a section of tubing connected to each aperture and containing a porous non-absorbent substance for the passage of gas and vapors therethrough, a wire network mounted on the ring, and a plurality of buoys fastened to the network, said buoys maintaining the cover above the surface of the liquid and imparting greater buoyancy near the center than toward the edge of the cover.

2. A four-phase system for minimizing the evaporation losses of volatile liquids whose vapor pressure at maximum storage temperature does not exceed one atmosphere while in a storage tank having a vent in its upper portion, comprising a liquid phase composed of the volatile liquid; a continuous vapor phase in equilibrium with the liquid phase; a solid phase of impervious material resting on, substantially entirely covering and supported in part by the vapor phase and including a plurality of non-collapsible upwardly extending tubes of sufficient height so that the hydrostatic head of a column of the vapor phase of that height will be equal in pounds per unit area to the unit weight of the

material of the solid phase; a gas phase of less density than the density of the vapor phase composed almost entirely of air above the solid phase and out of equilibrium with the liquid phase, said gas phase communicating with the atmosphere through the vent in the upper portion of the storage tank and with the vapor phase through the tubes.

3. A four-phase system for minimizing the evaporation losses of volatile liquids whose vapor pressure at maximum storage temperature does not exceed one atmosphere while in a storage tank having a vent in its upper portion, comprising a liquid phase composed of the volatile liquid; a continuous vapor phase one or more inches in thickness in equilibrium with the liquid phase; a solid phase of impervious flexible ma-

5 terial resting on, substantially entirely covering and supported in part by the vapor phase and including a plurality of non-collapsible upwardly extending tubes of sufficient height so that the hydrostatic head of a column of the vapor phase of that height will be equal in pounds per unit area to the unit weight of the material of the solid phase and a porous non-absorbent substance in each tube; and a gas phase of less density than the density of the vapor phase composed almost entirely of air above the solid phase and out of equilibrium with the liquid phase, said gas phase communicating with the atmosphere through the vent in the upper portion of the storage tank and with the vapor phase through the tubes.

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