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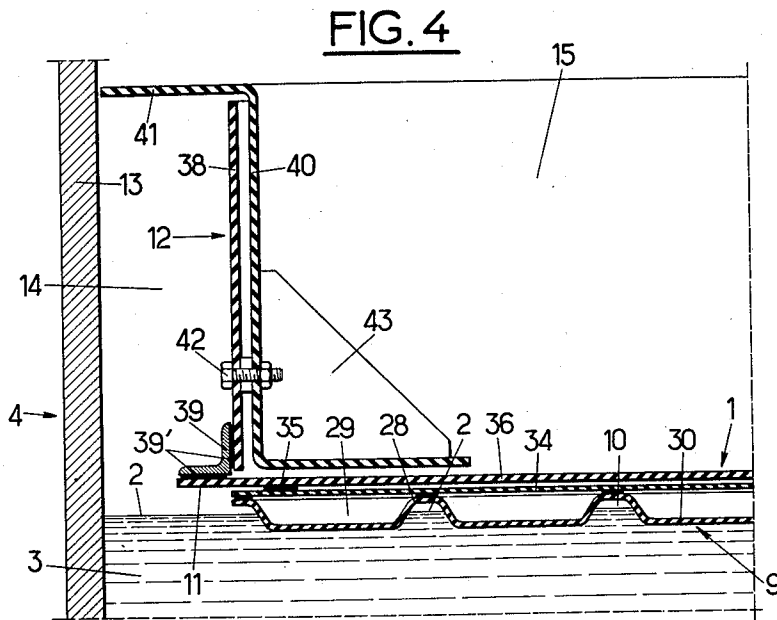
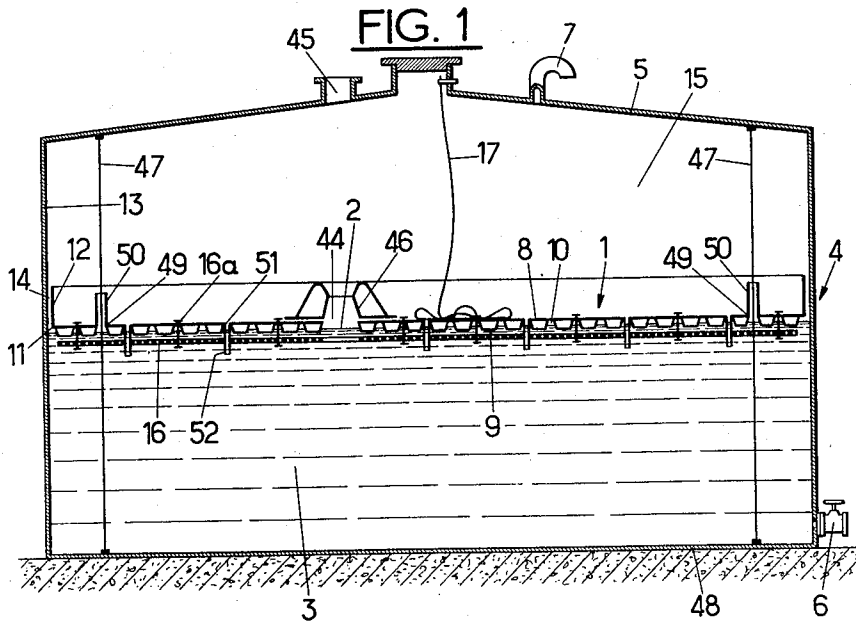
A. CHAMPAGNAT

2,867,346

FLOATING PLASTIC SCREEN

Filed Sept. 26, 1955

2 Sheets-Sheet 1



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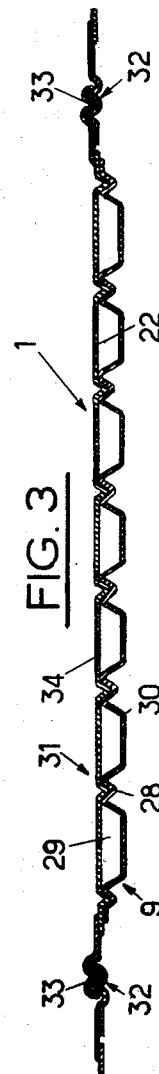
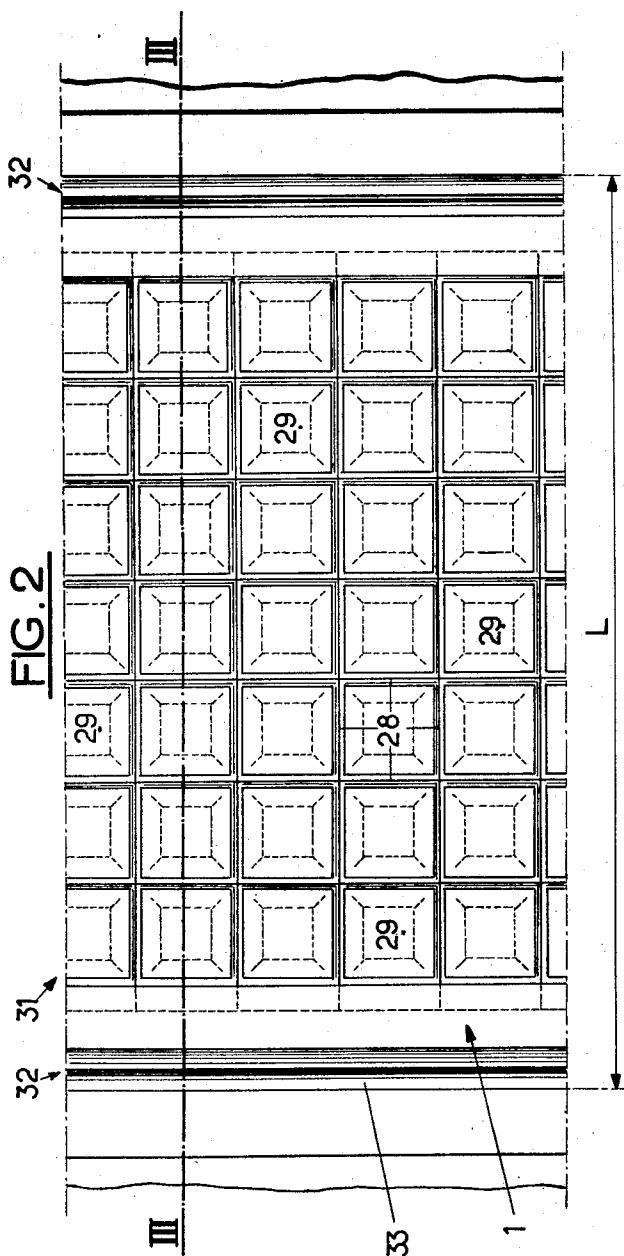
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2,867,346

## FLOATING PLASTIC SCREEN

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Application September 26, 1955, Serial No. 536,550

Claims priority, application France October 6, 1954

19 Claims. (Cl. 220—26)

This invention relates to devices for the protection of volatile and non-volatile liquids stored in reservoirs, and relates more particularly to floating screen or blanket devices for protecting such liquids stored in tanks, particularly tanks of the fixed-roof type. This invention is of utility especially in tank storage of volatile liquids whose vapor pressure at the storage temperature does not exceed atmospheric pressure, particularly such liquids as petroleum distillates, crude petrol, and volatile alcohols, and is of utility also in tank storage of wine and other liquids, volatile or non-volatile, which undergo alteration in the presence of air.

Objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious therefrom, or may be learned by practice with the invention, the same being realized and attained by means of the combinations, improvements and instrumentalities pointed out in the appended claims.

The invention consists in the novel parts, constructions, arrangements, combinations and improvements herein shown and described.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate several embodiments of the invention, and together with the description, serve to explain the principles of the invention.

The present invention has for its object an improved device for the protection of liquids stored in reservoirs and, more particularly, a device principally intended to reduce losses by evaporation in storage tanks for volatile liquids whose vapour pressure at the storage temperature does not exceed atmospheric pressure.

A further object of the invention is to provide means to ensure a good separation between the ambient air and the free surface of the stored liquids so as to avoid an alteration of the latter.

A further object of the invention is a device intended to reduce in a considerable degree the risk of explosion and fire during the storage of inflammable volatile liquids.

A still further object of the invention is a device intended to cooperate with an existing cylindrical reservoir with vertical axis, of circular or non-circular cross-section, of the fixed roof type (conical roof), without the necessity of dismantling or modifying the latter, and to reduce considerably the losses by evaporation of the stored liquids and the risk of fire if the liquids are inflammable.

According to an essential characteristic of the invention there is made to float on the free surface of the liquid stored in the reservoir with fixed roof a light flexible screen (blanket) made of a plastic material unattackable by the stored liquid, the surface or the screen being a little smaller than the cross-section of the reservoir and provided at its periphery with a vertical apron also made of plastic material.

It has been suggested already to reduce the losses by evaporation in reservoirs with fixed roof by arranging a screen on the liquids.

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For example, it has been suggested to make to float on the stored liquids devices similar to floating roofs constructed wholly or partly in metal and therefore rigid.

It has also been proposed to arrange on floats, varying in numbers and construction, flexible floating screens made, for example, of fabrics impregnated with synthetic resin, the whole floating on the liquid to be stored.

The known devices were intended either to float directly on the liquid phase without a vapour phase being interposed between the surface of the liquid and the screen, or they were arranged at a certain distance above the liquid, with a vapour phase between the free surface of the liquid and the floating screen, and the communication between that vapour phase and the wall of the reservoir being closed so as to prevent the vapours of the liquid from escaping at the periphery of the floating screen.

In all embodiments suggested up till now, the screens or analogue devices pressed strongly against the vertical walls of the reservoir, either directly or by the intermediary of a joint made of elastic or rigid material.

Now, it is well known that the inner walls of storage reservoirs with vertical axis are not in the form of geometrically perfect cylinders; their vertical walls are formed by rings joined by riveting or soldering whereby projections at the inner surface of the cylinder are caused. Moreover, the sheet metal hoops of the reservoir often are inclined towards the vertical so that they may interlock, in consequence of which the diameter of the reservoir is not strictly constant at all levels.

Experiments carried out by the applicant have shown that floating screens which press too strongly against the walls of the reservoir are caught or wedged by the unevenness or irregularities of the walls when the level of the liquid is changed.

For this reason, according to an essential characteristic of the invention, the new floating screen conceived by the applicant has a diameter distinctly smaller than the diameter of the reservoir so as to leave on its periphery a clearance of a magnitude such that substantially all catching and wedging by the unevennesses of the reservoir walls is avoided when the screen rises or falls with the level of the liquids to be protected. In general, a clearance of at least 20 mm. will be found sufficient for the purpose although a greater or less clearance may be required or be feasible, as the case may be, in some installations.

Moreover, the floating blanket according to the invention is made of a flexible elastic material in the form of sheets or films which are very thin, which is not seriously attacked by the stored liquid, is sufficiently flexible to be deformed when submitted to stresses resulting from being caught by the unevennesses of the inner walls of the reservoir, and is sufficiently elastic to resume its original form when it is past the unevenness. In the usual case of storing hydrocarbons and alcohols the material used to manufacture the blanket according to the invention is a flexible elastic synthetic resin or polymer, sometimes hereinafter referred to as plastic material, in the form of sheets or films which are very thin and is, preferably pure, that is non-plasticized, polyvinyl chloride in the form of sheets or films having a thickness in the range of from some hundredths to some tenths of a millimeter; however, the blanket may also be made of other plastic materials such as polyvinyl chloride-polyvinyl acetate copolymers, other vinyl co-polymers, vinylidene chloride, superpolyamides, fluorinated polymers such as polytetrafluoro-ethylene (commercially being marketed as "Teflon") and polymonochlorotrifluoro-ethylene (fluorocarbon), and polyethylene terephthalate and other polyester resins, with similar chemical properties provided that these materials are not seriously attacked by the

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stored liquids. The fluorinated polymers, in particular, are resistant to temperatures appreciably exceeding 100° C. which allows cleaning of the reservoirs with steam which is easily available in petroleum refineries.

To ensure the floating of the blanket on the liquid to be stored, it is provided, according to another characteristic of the invention, with floats made of the same or a similar plastic material and attached in the form of hollow cells to the lower surface of the blanket.

Since the floating blanket according to the invention leaves a free annular liquid surface beyond its periphery, it is, according to another characteristic of the invention, fringed with an apron, which in general is substantially vertically arranged and has a height of a magnitude so as to maintain, above the free annular liquid surface and at the walls of the reservoir, a circular ring of gas in equilibrium with the stored liquid whereby the losses by evaporation on that free annular surface are restricted in a considerable degree. In general, an apron height of at least 200 mm. is preferred although a greater or lesser height may be found suitable for particular installations and particular materials. In effect, the volume of the annular space mentioned is filled with air practically saturated with the vapours of the stored liquid whose density is greater than that of air without vapours so that the evaporation of the stored liquid is impeded, and the only possible losses are due to the diffusion of the atmosphere of the annular space into the vapour phase of the reservoir. Now, it is known that the diffusion of gases is a much slower process than evaporation.

The experiments of the applicant have shown that the losses by evaporation are reduced to about a fifth or a tenth of what they would otherwise be, by the use of the vertical apron mentioned above.

Moreover, according to an additional characteristic of the invention, it is possible to counteract the diffusion of the gases between the annular space and the vapour phase of the reservoir by closing, more or less completely, the annular space at its upper part. This closure may be effected by an appropriate shape of the vertical apron, for example by giving the apron the form of a Z or of an inverted L. This shape is feasible thanks to the construction of the apron by a film of plastic material of very slight thickness (10 to 20 hundredths of a millimeter). Such a film is, in fact, sufficiently deformable and elastic to offer no appreciable resistance when it encounters a ring of rivets, for example, in the course of variations of the liquid level.

There is thus effected, according to the invention, even if the vertical apron has not the form of a Z or of an inverted L, but even more so if it has this shape, a gaseous seal between the periphery of the floating blanket and the wall of the reservoir. This gaseous seal is infinitely deformable and contact between the edge of the blanket (or the upper part of the apron) and the wall of the reservoir is only made along a line, or zone, of very slight thickness, practically equal to the thickness of the film of plastic material (some hundredths of a millimeter).

Moreover, since the diameter of the blanket is distinctly smaller than that of the reservoir, contact is never made over the whole periphery of the blanket so that the surface of the total zone of contact (length of the line of contact multiplied by the thickness of the film) is further reduced.

Since the line or zone of contact is extremely flexible, one does not meet, in accordance with the invention, any of the disadvantages of the earlier proposed devices, such as catching, etc., and the gaseous seal achieved according to the invention restricts in an effective manner the losses by evaporation.

In the preferred embodiment of the invention there is attached to the blanket a flat metallic element, electrically connected to the material of the reservoir. One

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may, for example, provide on the lower surface of the blanket a metallic netting covering that surface completely, or at the upper surface of the blanket a thin metal sheet, the netting or metal sheet being connected electrically to the material of the reservoir by a flexible conducting wire.

In this way there is obtained an electric blanket which collects and carries away to the material of the reservoir the electrostatic charges produced through the pumping of the non-conducting liquids, such as the hydrocarbons, and the production of sparks which otherwise could cause explosions in the gaseous phase is thus made impossible.

There will now be described, in order to illustrate the possibilities of carrying out the invention, without thereby in any way restricting the scope of the invention, embodiments shown by way of example and represented in the attached schematical drawing as follows:

Fig. 1 is a vertical section through a reservoir with fixed roof equipped with a floating blanket according to one embodiment of the invention.

Fig. 2 is a view on a larger scale of part of the floating blanket according to another embodiment of the invention.

Fig. 3 is a section along the line III—III of Fig. 2.

Fig. 4, finally, is a vertical section of part of the floating blanket with vertical apron according to still another embodiment of the invention.

With special reference, in the first instance, to the embodiment of Fig. 1, it is seen that a device according to the invention essentially comprises a floating blanket 1 on the surface 2 of a volatile liquid 3 contained in reservoir 4 with fixed (conical) roof 5 provided with a valve 6 for filling and emptying and a respiratory orifice 7.

In its preferred form for use with hydrocarbon liquids and alcohols, the blanket 1 comprises, preferably, a continuous sheet 8 of pure, that is non-plasticized, polyvinyl chloride of a thickness which, preferably, is in the range of from about 10 to about 20 hundredths of a millimeter. Blanket 1 is supported by hollow floats 9 also made of a very thin film of pure polyvinyl chloride, as will be explained below.

The level 2 of the liquid is always situated below the upper sheet 8 which constitutes the blanket in the proper sense. The vapour phase 10 between floats 9 and below the upper sheet 8 has, preferably, a thickness of the order of a few millimeters. Stated otherwise, the upper sheet 8 is maintained by means of floats 9 at a distance of less than half an inch above the free surface or level 2 of the stored liquid.

The blanket 1 is of a diameter distinctly smaller than the diameter of the reservoir 4 and is fringed around its periphery 11, preferably, with a vertical apron 12 which leaves an annular clearance space or interval 14 of at least 20 mm. span between that periphery and the inner wall 13 of the reservoir. The height of the vertical apron 12 is, preferably, at least 200 millimeters.

The annular space 14 comprised between the vertical wall 13 of reservoir 4 and apron 12 which fringes blanket 1 is thus constantly filled with air saturated with the vapours of the stored volatile liquid 3. The gaseous ring-shaped space 14 behaves as an infinitely deformable seal which takes the exact shape of the wall 13 of the reservoir when the level 2 of liquid 3 is varied by filling or discharge through valve 6, and evaporation into the main vapour phase 15 of the reservoir is impeded by the presence, above the free surface 2 of liquid 3, of that gaseous space 14 saturated with the vapours of the volatile liquid.

As shown above, the passage of the vapours of the volatile liquid 3 into the vapour phase 15 of the reservoir is now only still dependent on the diffusion of the molecules of the volatile liquid 3 out of the annular space 14 which diffusion is a much slower process than evaporation.

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The effect of the floating blanket with its vertical apron is thus to restrict considerably the rate at which the vapour phase 15 of the reservoir is enriched with the vapours of the stored liquid 3. An equilibrium establishes itself between the emission of vapours of liquid 3 above the vertical apron 12 and the loss of air, charged with these vapours, during each daily respiration of the reservoir through the respiratory orifice 7, in such a manner that the concentration of the vapours of the stored liquid in the vapour phase 15 of the reservoir is always much lower than would be the concentration in that phase without the floating blanket according to the invention. The result of the shown arrangement is a reduction of at least 75%, and mostly of 80 to 90%, of the respiration and filling losses.

In certain cases it is possible that the vapour phase 15 above the floating blanket 1 has a concentration of the vapours of the stored liquid 3 within the range of inflammability, provided liquid 3 is inflammable.

On the other hand, it is known that when a reservoir is filled with an electrically non-conducting liquid (for example with hydrocarbons) the friction of the non-conducting liquid on the walls of the filling pipe line causes the non-conducting liquid to be charged with negative static electricity, and that this phenomenon of static electrification is the cause of numerous fires or explosions which occur in reservoirs or inflammable products, such as petroleum products.

It is possible to reduce to a minimum and even to eliminate the danger of fire and explosions by fixing, according to an additional characteristic of the invention, on the lower surface of the blanket, by any suitable means, for example, by metal hooks 16a going through blanket 1, a metal netting 16 which covers the whole lower surface of the blanket. This netting 16 is electrically connected to the material of the reservoir by at least one flexible conducting wire 17 of copper or other suitably electrically conductive material, of sufficient length to allow the displacement of blanket 1 between its upper position, when the reservoir is full, and its lower position, when the reservoir is empty. In this manner there is achieved an electric screen connected electrically to the metallic roof of reservoir 4. This screen 16 collects the whole of the dangerous electric charges present on the surface of liquid 3 and discharges them to the material of the reservoir from which they may flow to ground.

The vapour phase 15 of reservoir 4 where explosive gas mixtures may accumulate is thus completely protected against electric charges which might cause sparks so that all dangers of explosion or fire due to static electricity are absolutely eliminated.

It will be understood that it is possible to achieve the same protection by arranging, instead of the metal netting 16 attached to the lower surface of the blanket, a netting or, for preference, a thin flexible metal sheet fixed to the upper surface of the blanket and electrically connected to the material of the reservoir in the same manner as in the embodiment represented in Fig. 1.

In any case, it is a matter of using a plastic material obtainable in the form of very thin films which alone allow to achieve the flexibility and elasticity desired for the blanket according to the invention. In this manner there is obtained a very light blanket which offers the further advantage that it may be constructed and transported in sections to the reservoir where it is to be installed. The sections of the blanket can be introduced into the reservoir through a manhole and assembled in the reservoir without any alteration of the reservoir.

In the construction of the sectional blanket of this invention, for preference are used thin sheets of a plastic material which is industrially produced in the form of very long ribbons, about 0.70 to 1.0 m. wide. It is then easily possible to make a circular blanket, according to the invention, of suitable diameter, by assembling these

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ribbons or bands placed side by side and then cutting the rim in circular form.

The bands may be assembled, for example, by welding, cementing, or for preference, according to another characteristic of the invention, by means of sliding fasteners which latter will below be shown in more detail with particular reference to Figs. 2 and 3.

The floats 9 may be of any kind but, according to one characteristic of the invention, the floats used, for preference, are in the form of hollow cells made of a thin film of the plastic material used for the blanket proper. The floats may be independent of the blanket but they may also form an integral part of it which results in the blanket floating by itself (auto-floating blanket) without separate floats being attached to it.

In Figs. 2 and 3 is represented a particular embodiment of an auto-floating blanket 1 made from individual bands 31 of plastic material assembled as at 32 with sliding fasteners 33.

In the embodiment represented in Figs. 2 and 3, a film 30 of plastic material having a great number of square cells 29 in its surface is hermetically sealed, as by welding or glueing around the rim 28 of each cell, to the lower surface 22 of the blanket film 34 so as to provide the floats 9 filled with air. These cells 29 are obtained for example by forming depressions in the film 30 of polyvinyl chloride or of another plastic material of the same kind as that of the blanket film 34.

Such auto-floating sectional blankets may be mass produced from individual bands 31 of the plastic material, of great length and a width L of, for example, 0.70 to 1.0 m., which then are assembled as at 32 by sliding fasteners 33 as will be described below.

The floating blanket 1 may also be constructed (see Fig. 4) by using, as independent floats, square or rectangular elements obtained, for example, by the process mentioned above, that is by welding or glueing a film 34 of plastic material onto another film 30 of plastic material in which latter there have previously been vacuum moulded a great number of small cells 29.

Sections of the assembled films 30 and 34 (which sections are in general smaller than the bands 31 in the construction) are adhesively bonded or otherwise fixed at 35 under a third film 36 of plastic material which constitutes the upper surface of blanket 1.

The transport of the floating blankets according to the invention and their introduction into the inside of the reservoir, and also the mounting of the blanket in the reservoir, are tasks which may easily be carried out in the following manner:

The floating blanket 1 with its cellular floats 9 fixed at its lower surface 22 may be rolled like a tobacco leaf forming a cigar, so as to facilitate its transport and to allow its introduction, through a manhole, into the reservoir. However, in the case of reservoirs with a greater diameter than about 8 m., the length of the rolled blanket also exceeds 8 m. which makes it difficult to transport. Moreover, the manholes of the reservoirs have a diameter of the order 70 cm. which does not allow the introduction of rolled blankets of very great diameter. For these reasons it is necessary to separate the floating blankets into sections not exceeding the dimensions of about 8 m. by 15 m., these sections, constructed in advance, being transported in the form of rolls and introduced through the manhole into the reservoir to be equipped.

According to one characteristic of the invention, in order to make possible a rapid and efficient assembling of these elements (as well as the assembling of the bands of width L in the construction of the blanket) there are provided sliding fasteners 33, with or without hooks, along the assembling line which allows to carry out the assembling of the various parts or of the sections inside the reservoir 4 easily and more quickly.

The sliding fasteners 33 are preferably without hooks and made of a plastic material of the same kind as that

of floating blanket 1. They are relatively impervious to the liquids or gases under slight pressure but it is advantageous to improve the imperviousness of these fasteners by coating the plastic material used with an adhesive varnish, or better still by covering them with an adhesive ribbon made of a fabric or a plastic material coated with such a varnish.

It has been indicated previously that the effectiveness of the floating blanket must be completed by attaching, along its periphery 11, an apron 12, of generally vertical form, which apron also is made of plastic material.

Apron 12 may be fixed to periphery 11 of the blanket by welding, cementing, by sliding fasteners, or any other means. It may be of any suitable shape so as to maintain, between the periphery 11 of the blanket and the walls of the reservoir 4, a circular space 14 filled with air saturated with the vapours of the stored liquid 3. It may be fixed in advance on the circular rim 11 of the sections of blanket 1, or else it may be fitted when the blanket has been mounted inside reservoir 4.

The vertical apron 12 may with advantage be equipped with reinforcing elements, mouldings, or similar means so that it may rapidly take on again its generally vertical form if, by accident, it should be deformed, for example by being caught by the unevennesses of the walls of reservoir 4.

It is, of course, necessary to increase the number and/or the volume of the floats 9 arranged under the periphery 11 of blanket 1 to balance the weight of the vertical apron 12. For the sake of simplification, this increase in the number and/or volume of the floats is not represented in the drawing.

In a preferred embodiment represented in Fig. 4 the vertical apron 12 consists of a film 38 of polyvinyl chloride fixed to the periphery 11 of blanket 1 by means of flexible angle pieces 39 made of plasticized polyvinyl chloride with welded joints 39'. The film 38 is very thin (10 to 20 hundredths of a millimeter thick) and would not maintain its vertical position unless reinforced, as shown, by another film 40 which is also very thin. This film 40 may with advantage be folded back to form a flange 41 which closes, more or less completely, the gaseous ring 14 comprised between apron 12 and the walls of reservoir 4.

Films 38 and 40 are fitted together with press buttons, or better by means of bolts and screws 42.

Film 40 has stiffeners 43, placed at regular distances, which prevent the whole of apron 12 from inclining towards the interior of the reservoir, or in case the position should have been changed accidentally, for example by the effect of certain unevennesses, allow the apron to take up again its former position. Film 40 may also be moulded into a corrugated form so as to have a greater elasticity with respect to deformations.

As regards the construction, it may be noted that it is advantageous to equip the blanket, while it is being constructed, with the fixed film 38 which is folded and rolled together with blanket 1 for the transport to the reservoir, while film 40 is easily fitted on blanket 1 when the latter is already in place in the reservoir and is thereby provided with the necessary hold.

In order to allow gauging and sampling in the reservoir it is desirable to provide in the floating blanket at least one orifice 44 (Fig. 1) of a diameter sufficiently large to allow the passage of the instruments for gauging and sampling. Such an orifice 44 is placed exactly below the vent 45 provided in roof 5 of reservoir 4 to allow gauging and sampling. Each orifice 44 is preferably bordered by a skirt 46 which is practically vertical and is intended to maintain at the free surface 2 of liquid 3 an atmosphere of air saturated with the vapours of liquid 3. This skirt 46 has the form of a double cone to allow the introduction and the withdrawal of the sampling vessel without the latter being caught at the walls of orifice 44.

In order to maintain the position of gauging orifice 44 of blanket 1 below vent 45 it is necessary to prevent any rotation of blanket 1 which may be achieved, for example, by stretching two vertical cables 47 between roof 45 and bottom 48 of reservoir 4. These cables 47 pass through the blankets by holes 49 provided for the purpose. These holes 49 are bordered by a collar 50 also of polyvinyl chloride so as to restrict losses by evaporation.

Moreover, it is desirable to provide in the floating blanket holes 51 of very small diameter to allow the drainage of water of condensation which may accumulate on blanket 1.

In order to prevent the vapours of liquid 3 enclosed below blanket 1 from escaping through holes 51, there are provided, with advantage, tubes 52 of flexible plastic material, soldered below the blanket and abutting upon discharge holes 51, which tubes 52 are immersed in the stored liquid 3.

When reservoir 4 is provided with a swing line, there is with advantage provided in blanket 1 a groove of suitable length (not shown in the drawing) intended to allow the passage of the swing line. Such a groove is bordered on each side by a vertical apron to restrict evaporation.

The following are examples of various ways of carrying out this invention:

#### Example 1

A plastic floating screen of pure polyvinyl chloride was constructed for a riveted reservoir having a diameter of 12 m. and a height of 12 m. intended for storing a stabilized gasoline of a density of 0.720 at 15° C.

The pure polyvinyl chloride used had the following characteristics:

|                      |                                          |
|----------------------|------------------------------------------|
| Specific gravity     | 1.4.                                     |
| Tensile strength     | 8,000 p. s. i. (pounds per square inch). |
| Compressive strength | 11,000 p. s. i.                          |
| Flexibility strength | 14,000 p. s. i.                          |
| Izod impact          | 0.8 ft./lbs. per inch in notch.          |
| Elasticity modulus   | 300 kgs./sq. millimeter.                 |

The screen consisted of 17 strips 70 cm. wide of film of a thickness of 20/100 mm. in thickness. Under said strips there were welded plates with hollow cells (alveoli) having 560 alveoli of 9 cm.<sup>3</sup> per square meter, 10 mm. deep, constructed, as in Figs. 3 and 4 of molded and welded film of 15/100 mm. thickness. The strips were assembled in advance edge to edge by means of sliding fasteners made of polyvinyl chloride without hooks.

The vertical skirt or apron was constructed as in Fig. 4; the part of the skirt 38, made of film of 15/100 millimeter, was welded in advance onto the periphery of the screen to be transported with it.

For purposes of transportation the screen was divided into two elements by opening the sliding fastener which went through a diameter. The two elements were then rolled up in the form of a cigar 6 meters long, with a diameter of 0.5 meter each weighing 60 kgs. The two rolled up elements were introduced into the reservoir through a manhole 0.70 m. in diameter. They were then assembled in the interior of the reservoir by closing the sliding fastener which had been sealed by applying an adhesive insoluble in the gasoline. Previously a metal grid 11.90 m. in diameter had been introduced into the reservoir which grid was fixed under the plastic screen by means of metal hooks. This grid shown at 16 Fig. 1 is the electric screen for the elimination of static electricity. It was grounded to the reservoir by means of 3 flexible cables 17.

The mounting of the vertical skirt of Fig. 4 was completed in the reservoir by fixing by means of bolts 42 the part 40 of polyvinyl chloride film elements having a corrugated form and being of a thickness of 50/100 mm. Thereupon the supplementary devices were in-

stalled, viz. double funnel 46 for gauging and sampling, and the cables 47 for preventing the screen from turning.

The installation took 20 hours and occupied 2 workmen. The plastic floating screen thus constructed and installed leaves a clearance of from 2 to 3 cm. between its periphery and the wall of the reservoir, which latter is not a perfect cylinder on account of its being constructed with superposed hoops of sheet metal.

The following are its characteristic features (not counting the metal grid which weighs 300 gr. per m.<sup>2</sup>):

Weight per square meter----- 1 kg.  
Apparent density----- 0.2 kg.  
Floatability (per square meter on gasoline of a density of 0.7) .. 3100 kg. (which it can sustain before sinking).

After the gasoline has been introduced into the reservoir the screen follows the variations of its level, the superior film of the screen being 5 mm. above said level, without clinging in a troublesome way to the rows of rivets, and the operations of gauging and sampling proceed in the usual way.

The losses by evaporation in the reservoir equipped with this floating screen and in an identical control reservoir without screen the two placed side by side, have been measured. The two reservoirs were filled with the same gasoline of density 0.720 at 15° C. and Reid vapor pressure of 0.650 kg./cm.<sup>2</sup> at 100° F. and they were emptied in a parallel manner in one month according to the needs of operation.

The measurement of the losses was effected by two methods.

(a) Determination of the hydrocarbon content of the vapor phase of the two reservoirs during a month at a mean temperature of 18° C.

|                                                                                       | Vapor phase           |                   |
|---------------------------------------------------------------------------------------|-----------------------|-------------------|
|                                                                                       | Reservoir with screen | Control reservoir |
| Concentration of hydrocarbons (average of 30 daily determinations): vol. percent..... | 1.93                  | 11.77             |

If estimated by this method the losses are thus reduced by 83.5%.

(b) Determination of butane in the gasoline of the two reservoirs at the beginning and the end of the storage of 1 month, the reservoirs being full at the beginning and almost empty at the end

|                                           | Reservoir with screen | Control reservoir |
|-------------------------------------------|-----------------------|-------------------|
| Beginning of storage, butane percent..... | 6.0                   | 6.0               |
| After 30 days, butane percent.....        | 5.95                  | 5.6               |
| Losses of C <sub>4</sub> .....            | 0.05                  | 0.4               |

The saving calculated by this method amounts to 87.5%.

#### Example 2

A floating plastic screen of pure polyvinyl chloride was constructed for a riveted reservoir 15 m. in diameter and 10 m. high, intended to store crude Kuwait petroleum.

The polyvinyl chloride used had the same characteristics as in Example 1, and the construction was identical. The screen had 22 strips 0.70 m. wide. There was no electric screen for crude petroleum is sufficiently conductive to avoid being charged electrically. The floating screen was transported in two rolls 7.50 meters long and of a diameter of 0.65 meter, each weighing 90 kgs. The insertion into the reservoir through a manhole and the mounting of the screen were accomplished as in Example 1. The work required 30 hours and 3 workmen.

The clearance between the periphery and the wall of the reservoir varies between 3 and 4 cm. The floatability of the screen is 3.6 kgs. per m.<sup>2</sup> on crude petroleum of a density of 0.865 at 15° C.

The Reid vapor pressure of the crude petroleum stored being 0.510 kg./cm.<sup>2</sup> at 100° and the mean temperature in the course of the storing period being 7° C., the losses by evaporation in the reservoir provided with the screen were compared with those in another reservoir without screen the two reservoirs being 1/2 full of the same crude petroleum.

The average of the hydrocarbon concentrations of the vapor phase during 12 days was 0.8% in volume in the reservoir with screen and 5.7% in the reservoir without screen.

The reduction of the losses by evaporation had thus been 86%. Moreover the odor of hydrogen sulfide was extremely attenuated through the presence of the floating screen.

#### Example 3

A welded reservoir 3 m. in diameter and 7 m. in height used for storing non-rectified ethyl alcohol was equipped with a floating screen of vinylidene chloride.

The vinylidene chloride used had the following characteristics:

Specific gravity----- 1.7.  
Tensile strength----- 5,000 p. s. i.  
Compressive strength----- 11,000 p. s. i.  
Flexibility strength----- 6,000 p. s. i.  
Izod impact----- 0.8 ft./lbs. per inch in notch.

The construction was identical with that of Examples 1 and 2, but films of 20/100 mm. were used for all the parts of the floating plastic screen. No electric screen was set up, for alcohol is not electrified by pumping.

The screen, weighing 8 kg. was transported rolled up as a single part 3 m. long and 0.40 m. in diameter. It was inserted in the reservoir through a manhole and the mounting of the vertical skirt was completed.

The work took 2 hours with a single workman.

It was found possible to reduce the clearance at the edge of the screen to 1 cm. on account of the welded and smooth walls of the reservoir.

The characteristics of the screen are the following:

Weight per m.<sup>2</sup>----- kg-- 1.02  
Apparent density----- 0.2  
Floatability per m.<sup>2</sup> on alcohol----- kg-- 3.2

Evaporation losses were measured by comparing them with those in an identical control reservoir located next to the first, said two reservoirs being half filled with the same non-rectified alcohol.

After 8 days of storage at a temperature of 22° C. in the liquid the concentration of alcohol vapors of the vapor phase of the reservoir with screen was 0.26% as against 6.2% in the control reservoir, so that the reduction of losses by evaporation attained 96%.

#### Example 4

A riveted reservoir, 4.5 meters in diameter and 7 meters high, intended for the storage of benzol was equipped with a floating plastic screen of polyethylene terephthalate having the following characteristics:

Specific gravity----- 1.3  
Tensile strength----- p. s. i-- 21,000

The construction of the screen was the same as that of the screens described before, but the assemblies were effected by cementing instead of welding, because polyethylene terephthalate is hard to weld. The upper face of the screen consisted of a film of 15/100 mm. and the hollow alveoli of film of 10/100 mm.

The elements of the screen were strips 0.70 m. wide

assembled edge to edge by cementing. The vertical skirt of 15/100 mm. film was likewise cemented. The screen rolled into a cylinder 4.50 meters long, weighing 8 kg., was inserted and mounted in the reservoir and its installation was effected in 5 hours by two workmen.

The clearance at the edges of the screen is 2 cm. Its characteristics are:

Weight per m.<sup>2</sup>----- 0.500 kg.  
Apparent density----- 0.1.  
Floatability on benzol----- 3.6 kg. per square meter.

The invention in its broader aspects is not limited to the specific combinations, improvements and instrumentalities described but departures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. The combination with a storage vessel for volatile liquids, the vessel having an upright wall and a fixed roof, of: a blanket comprising an upper thin sheet of flexible elastic plastic material and attached to the underside of said upper sheet, a plurality of small, contiguous, cellular float units, said float units comprising an upper thin sheet of flexible elastic plastic material having attached thereto another thin sheet of flexible elastic plastic material in which a plurality of contiguous hollow cells are provided, these two float unit sheets being attached one to the other around said cells to seal said cells individually and provide said plurality of small contiguous cellular float units, said blanket being capable of floating on the free surface of the stored liquid with said first mentioned upper thin sheet at a small distance from and in a parallel direction with the free surface of the stored liquid for protecting the same against evaporation, the blanket being of a size and configuration to cover substantially, but not entirely, the entire free surface of the stored liquid so as to leave only a narrow clearance between the periphery of the blanket and said wall providing a narrow free annular liquid surface between said periphery and said wall whereby catching and wedging by unevennesses of said wall is substantially avoided when the blanket rises or falls with the level of the stored liquid; and, an apron for said blanket, made also of at least one thin sheet of flexible elastic plastic material, which is of sufficient rigidity to be self-supporting yet sufficiently flexible to be deformed if submitted to stresses resulting from being caught by unevennesses of said wall, and sufficiently elastic to resume its original form when it has passed the unevennesses, said apron extending upwardly from said blanket and fringing the blanket around substantially its entire periphery in substantially wholly spaced relation to said wall for maintaining, above said narrow free annular liquid surface and at said wall, a ring of vapours in equilibrium with the stored liquid, whereby the losses by evaporation on the free annular liquid surface are restricted in a considerable degree.

2. A device as specified in claim 1, in which the flexible elastic plastic sheet material of both the blanket and the apron is unplasticized polyvinyl chloride.

3. A device as specified in claim 1, in which the flexible elastic plastic material of both the blanket and the apron is a polyamide synthetic resin.

4. A device as specified in claim 1 in which the blanket is sectional, being divided into a plurality of individual bands disposed side by side, each band comprising an upper strip of said flexible elastic plastic sheet material, sliding clasp fastener connecting means, provided along each edge of the upper strip of the band which is contiguous with an edge of an upper strip of an adjacent band, for connecting contiguous edges, and attached to the underside of the upper strip, a plurality of sealed float units, said float units comprising a strip of said

flexible elastic plastic sheet material having attached thereto another strip of said flexible elastic plastic sheet material in which a plurality of small, contiguous hollow cells are provided, the two float strips of each said band being sealingly attached one to the other around said cells to seal said cells individually and provide said plurality of sealed float units.

5. A device as specified in claim 4, in which upper strips of the bands, held together by said sliding clasp fasteners have applied thereto, over contiguous edges, an adhesive ribbon, whereby the fasteners are rendered less permeable to vapour and whereby the mechanical strength of the fasteners is augmented.

6. A device as specified in claim 1 in which the buoyancy provided by said float units is such that the upper sheet of the blanket is maintained by means of the float units at a distance of less than half an inch above the free surface of the stored liquid.

7. A device as specified in claim 1, in which said cells are disposed in an alveolar manner.

8. A device as specified in claim 1 including a metallic element forming an electrical screen attached to the blanket and connected to a metallic part of the reservoir by at least one electrically conducting wire.

9. A device as specified in claim 1 in which said apron is provided with an annular flange at its upper edge, which substantially completely closes the upper part of the annular space contained between the walls of the vessel and the apron, to substantially reduce the losses of vapours by diffusion.

10. A device as specified in claim 1, in which the apron comprises a cylindrical sheet of the flexible elastic material attached to the blanket, and a plurality of reinforcing members of flexible elastic plastic sheet material of greater thickness than said cylindrical sheet, said members being attached to said cylindrical sheet to provide a substantially complete segmental cylindrical wall in reinforcement of said cylindrical sheet.

11. A device as specified in claim 10, in which the reinforcing members are comprised each of a vertical section, forming part of the segmental cylindrical wall, a substantially horizontal arcuate section attached along the upper edge of said vertical section and providing an annular flange at the upper edge of the apron, which substantially completely closes the upper part of the annular space contained between the walls of the vessel and the apron, to substantially reduce the losses of vapours by diffusion, and a second substantially horizontal arcuate section attached along the lower edge of said vertical section and directed towards the center of the blanket.

12. A device as specified in claim 11 characterized in that the reinforcing members are stiffened into a corrugated shape and are reinforced with stiffening elements.

13. A device as specified in claim 1, in which the flexible elastic plastic sheet material of both said blanket and said apron is a synthetic resin.

14. The combination with an oil storage tank comprising rigid side walls and a fixed roof, a blanket comprising an upper thin sheet of flexible elastic plastic material and attached to the underside of said upper sheet, a plurality of small, contiguous, cellular float units, said float units comprising an upper thin sheet of flexible elastic plastic material having attached thereto another thin sheet of flexible elastic plastic material in which a plurality of contiguous hollow cells are provided, these two float unit sheets being attached one to the other around said cells to seal said cells individually and provide said plurality of small contiguous cellular float units, said blanket being capable of floating on the free surface of the stored liquid with said first mentioned upper thin sheet at a small distance from and in a parallel direction with the free surface of the stored oil for protecting the same against evaporation, the blanket being of a size and configuration to cover substantially, but not entirely,

the entire free surface of the stored oil so as to leave only a narrow clearance between the periphery of the blanket and said side walls providing a narrow free annular liquid surface between said periphery and said walls whereby catching and wedging by unevennesses of said walls is substantially avoided when the blanket rises or falls with the level of the stored liquid; a flexible elastic apron for said blanket made also of at least one thin sheet of flexible elastic plastic material, which is of sufficient rigidity to be self-supporting, yet sufficiently flexible to be deformed if submitted to stresses resulting from being caught by unevennesses of said wall, and sufficiently elastic to resume its original form when it has passed the unevennesses, said apron extending upwardly from the blanket and fringing the blanket around substantially its entire periphery in substantially wholly spaced relation to said side walls for maintaining, above said narrow free annular liquid surface and at said walls a ring of hydrocarbon vapours in equilibrium with the stored oil, the roof of said tank having at least one vent affording open communication between the upper part of the tank and the atmosphere.

15. An oil storage tank according to claim 14, in which said blanket and its apron consists essentially of unplasticized polyvinyl chloride in the form of sheets or films of a thickness in the range of from a few hundredths to a few tenths of a millimeter and in which said apron has a height of at least 200 millimeters.

16. An oil storage tank in accordance with claim 15, in which said apron is of a structural rigidity sufficient to maintain the apron in an erect position, and in which said blanket is of a construction to provide flotation cells at its underside in number and size sufficient to float said blanket on the oil at an elevation lower than ten millimeters.

17. A screen for protecting liquid contained in a storage vessel having an upright wall and a fixed roof, comprising an upper thin sheet of flexible elastic plastic material and attached to the underside of said upper sheet, a plurality of small, contiguous cellular float units, said float units comprising an upper thin sheet of flexible elastic plastic material having attached thereto a lower thin sheet of flexible elastic plastic material in which a plurality of contiguous hollow cells are provided, these two float unit sheets being attached one to the other around said cells to seal said cells individually and provide said plurality of small, contiguous, cellular float units, said blanket being capable of floating on the free surface of the stored liquid, and an apron of flexible elastic plastic material for said blanket disposed in a generally upright position relative to said blanket and fringing said blanket around substantially its entire periphery, said apron being of a structural rigidity sufficient to maintain said upright position when in use, yet sufficiently flexible to be deformed if submitted to stresses resulting from being caught by unevennesses of said wall, and sufficiently elastic to resume its original form when it has passed the unevennesses, the material of both said apron and said blanket being a synthetic resin, the different sheets of said material being of a thickness in the range of from a few hundredths to a few tenths of a millimeter, and said apron having a height of at least two hundred millimeters.

18. The combination with a storage vessel for volatile liquids, the vessel having an upright wall and a fixed roof, a blanket comprising a thin sheet of flexible elastic plastic material and attached to one side of said thin sheet, a plurality of small contiguous, cellular float units, said float units comprising a thin sheet of flexible elastic plastic material having attached thereto another thin sheet of flexible elastic plastic material in which a plurality of contiguous hollow cells are provided, these two float unit sheets being attached one to the other around said cells

to seal said cells individually and provide said plurality of small contiguous cellular float units, said blanket being capable of floating on the free surface of the stored liquid with the uppermost of said thin sheets at a small distance from and in a parallel direction with the free surface of the stored liquid for protecting the same against evaporation, the blanket being of a size and configuration to cover substantially, but not entirely, the entire free surface of the stored liquid so as to leave only a narrow clearance between the periphery of the blanket and said wall providing a narrow free annular liquid surface between said periphery and said wall whereby catching and wedging by unevennesses of said wall is substantially avoided when the blanket rises or falls with the level of the stored liquid: and, an apron for said blanket, made also of at least one thin sheet of flexible elastic plastic material, which is of sufficient rigidity to be self-supporting yet sufficiently flexible to be deformed if submitted to stresses resulting from being caught by unevennesses of said wall, and sufficiently elastic to resume its original form when it has passed the unevennesses, said apron extending upwardly from said blanket and fringing the blanket around substantially its entire periphery in substantially wholly spaced relation to said wall for maintaining, above said narrow free annular liquid surface and at said wall, a ring of vapours in equilibrium with the stored liquid, whereby the losses by evaporation on the free annular liquid surface are restricted in a considerable degree.

19. A screen for protecting liquid contained in a storage vessel having an upright wall and a fixed roof, comprising a thin sheet of flexible elastic plastic material and attached to one side of said sheet, a plurality of small, contiguous cellular float units, said float units comprising a thin sheet of flexible elastic plastic material having attached thereto a thin sheet of flexible elastic plastic material in which a plurality of contiguous hollow cells are provided, these two float unit sheets being attached one to the other around said cells to seal said cells individually and provide said plurality of small, contiguous, cellular float units, said blanket being capable of floating on the free surface of the stored liquid, and an apron of flexible elastic plastic material for said blanket disposed in a generally upright position relative to said blanket and fringing said blanket around substantially its entire periphery, said apron being of a structural rigidity sufficient to maintain said upright position when in use, yet sufficiently flexible to be deformed if submitted to stresses resulting from being caught by unevennesses of said wall, and sufficiently elastic to resume its original form when it has passed the unevennesses, the material of both of said apron and said blanket being a synthetic resin, the different sheets of said material being of a thickness in the range of from a few hundredths to a few tenths of a millimeter, and said apron having a height of at least two hundred millimeters.

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