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Azalbert et al.

[11] **3,736,754**

[45] **June 5, 1973**

[54] **RESERVOIRS FOR THE STORAGE OF LIQUIDS ESPECIALLY VOLATILE LIQUIDS**

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[30] **Foreign Application Priority Data**

Apr. 14, 1970 France.....7013376

[52] **U.S. Cl.**.....**61/.5,** 52/2

[51] **Int. Cl.**.....**B65g 5/00**

[58] **Field of Search** .....61/.5, 72.1; 220/26; 52/2; 135/4 R

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Assistant Examiner—Alexander Grosz
Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

This invention pertains to a reservoir with a very large capacity, in excess of 200,000 tons, for the storage of petroleum products.

A cavity, natural or artificial, is covered with a sheet **16** consisting of waterproof material that is also impermeable to petroleum products. A sheet **12,** essentially gasproof, supported by floats **13,** covers the surface of the liquid. The edges of sheets **12** and **16** are anchored in the concrete ring **6** which is poured above the talus. The upper portion of the roof **4** is also connected to ring **6.** The roof is inflated by fans which blow air between the envelope **4** and the sheet **12.** Cable **5** reinforces the roof, a ditch **11** moves the runoff waters along. A central collector **15** catches the infiltration water.

12 Claims, 8 Drawing Figures

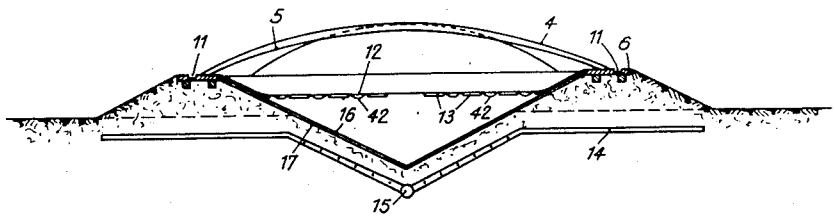


FIG. 1

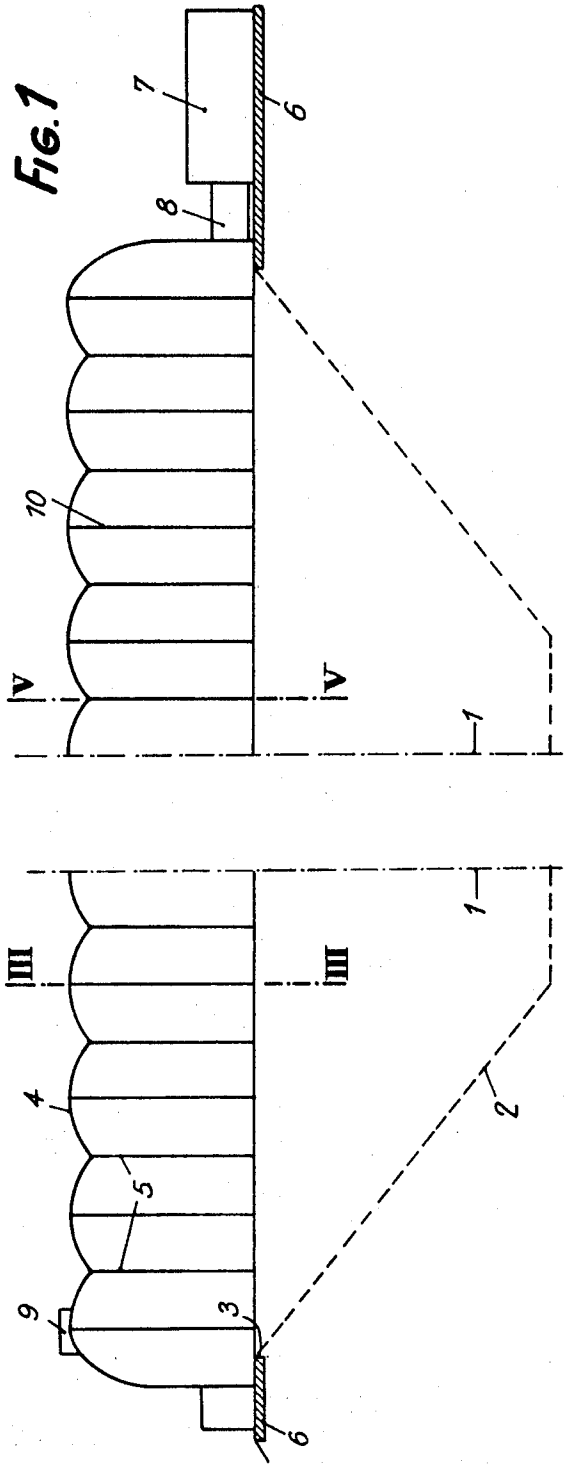


FIG. 3

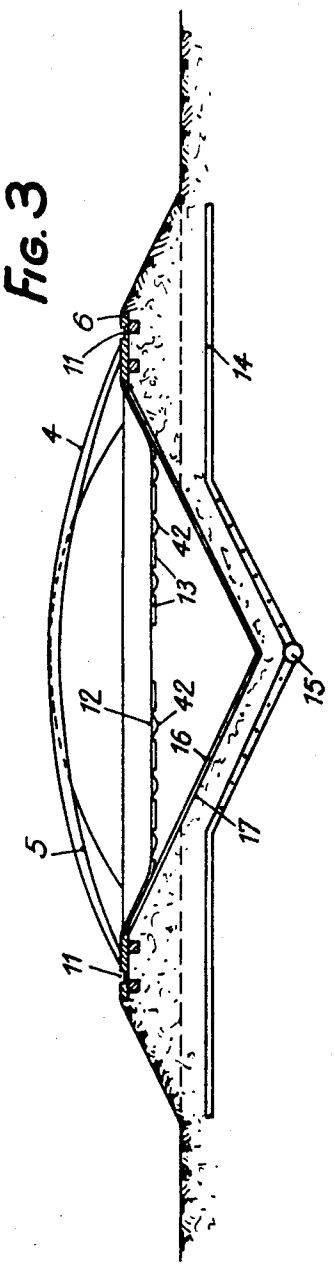


FIG. 2

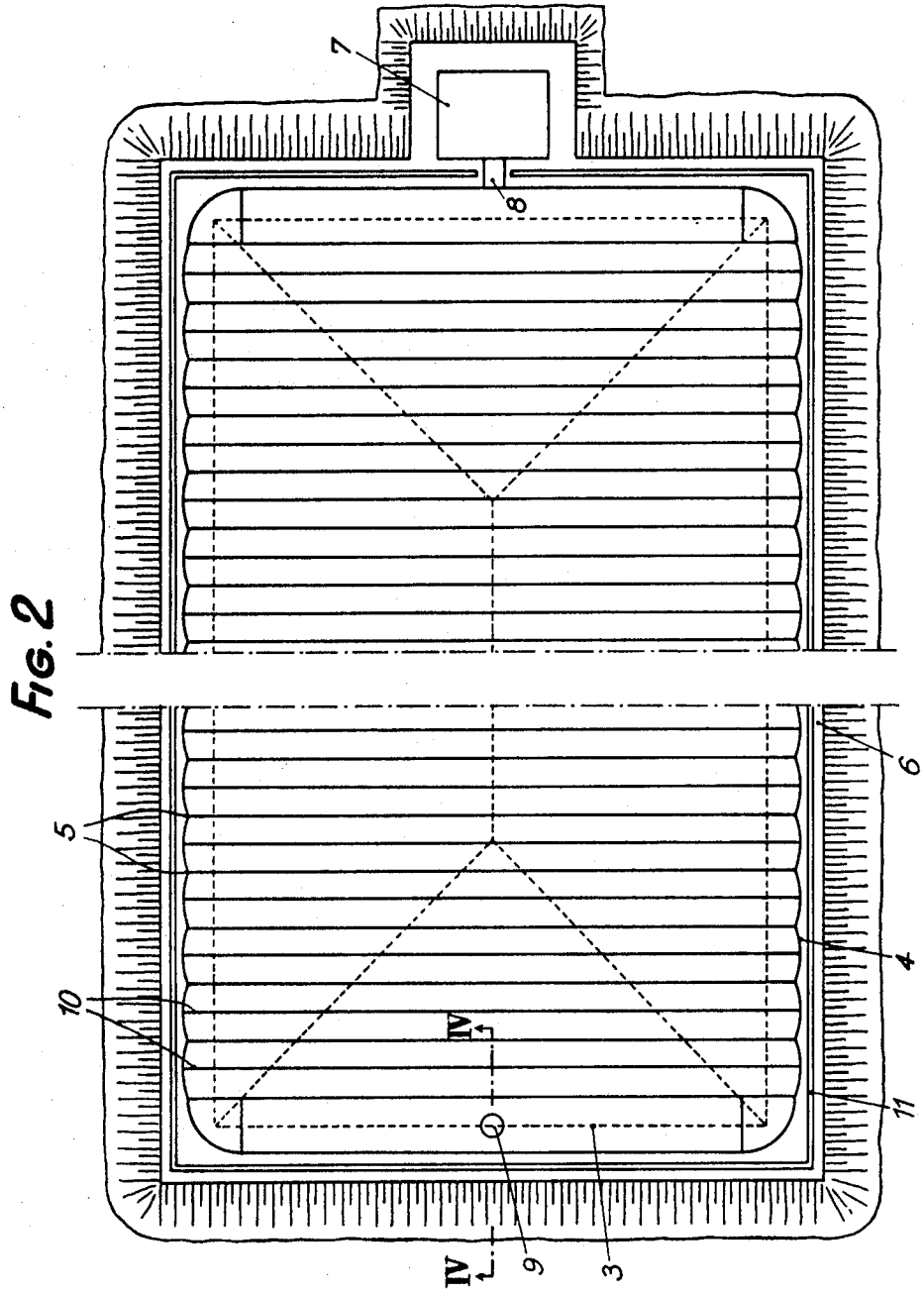


FIG. 4

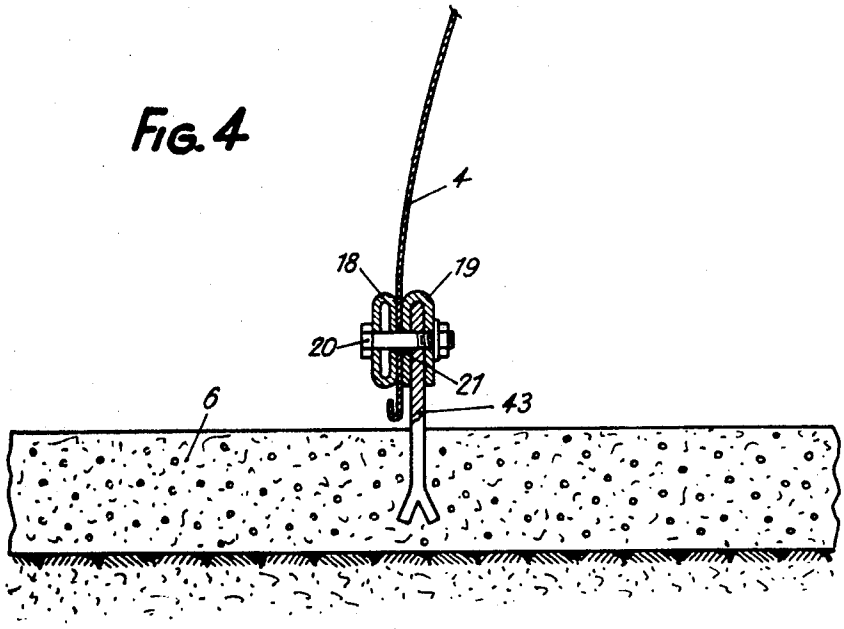
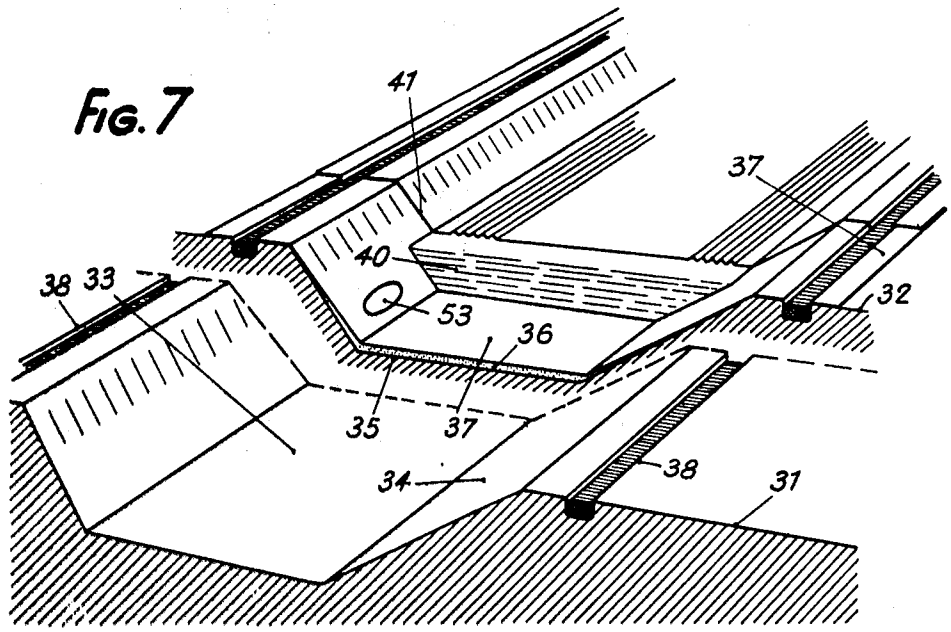


FIG. 7



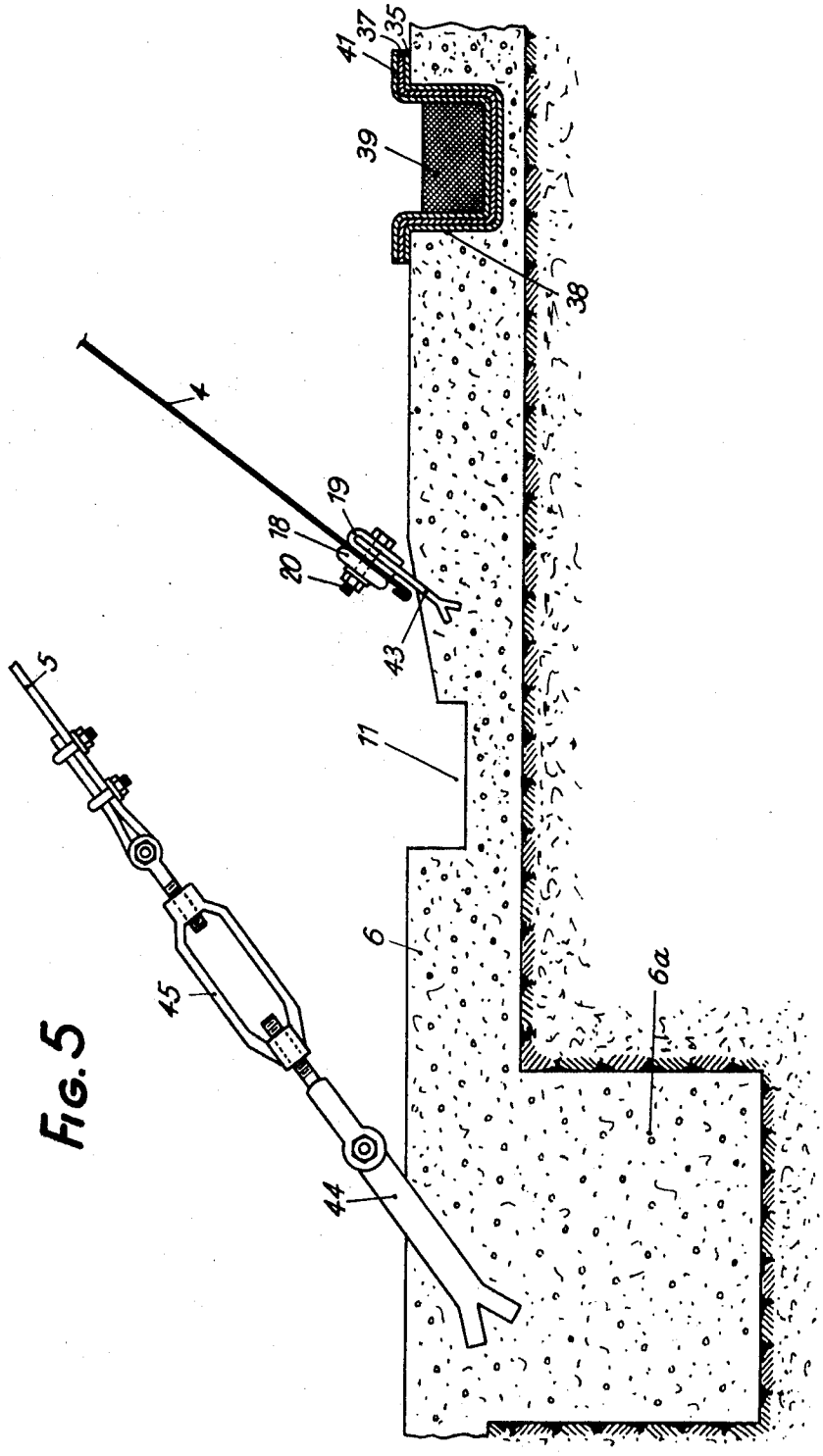


FIG. 5

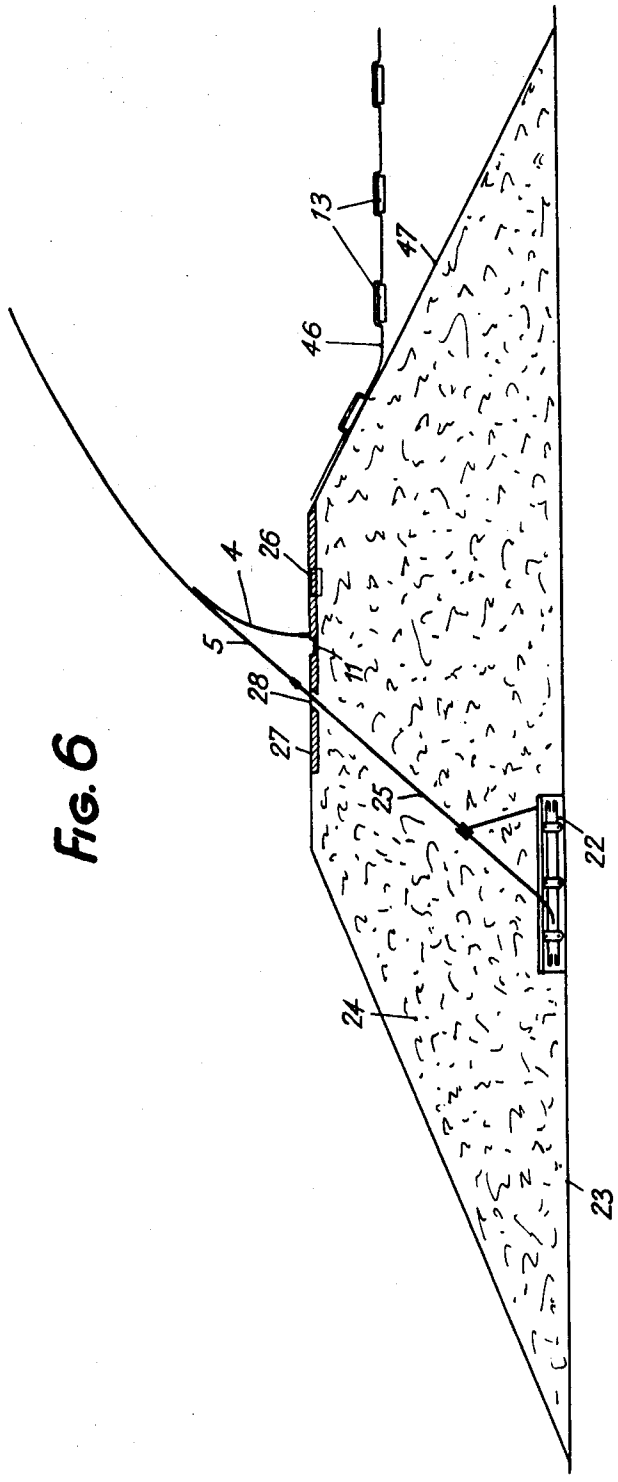
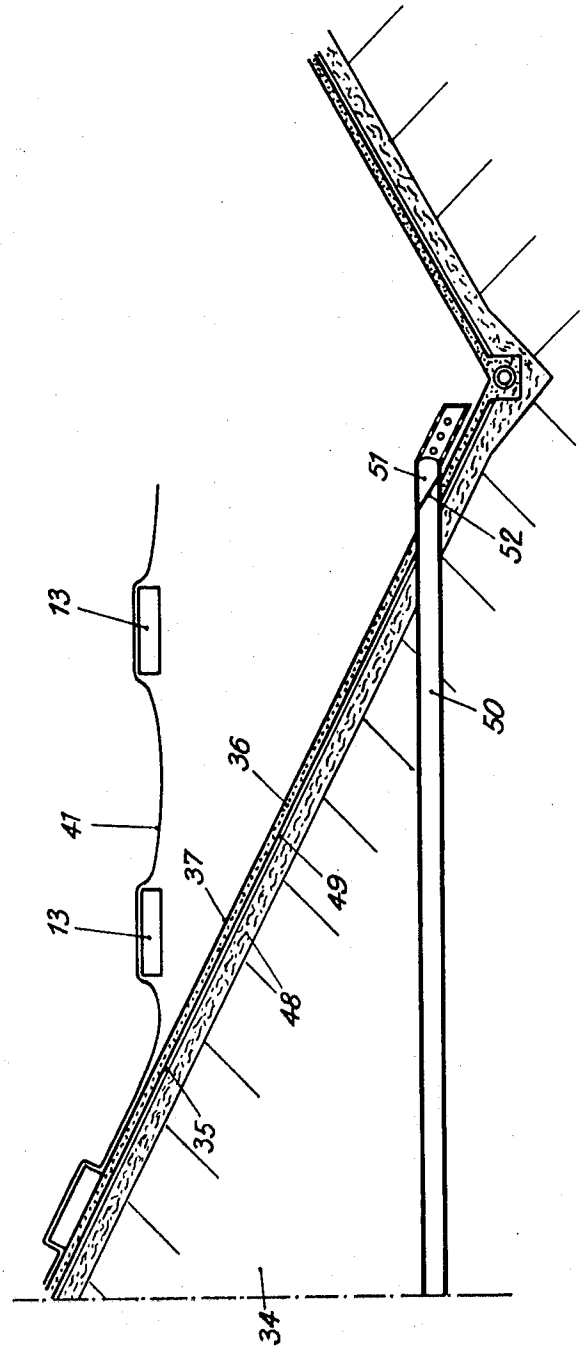


FIG. 6

FIG. 8



RESERVOIRS FOR THE STORAGE OF LIQUIDS ESPECIALLY VOLATILE LIQUIDS

The invention may be used for the storage of any volatile product.

This invention relates to a device for the storage of liquids and especially volatile liquids or liquids that have not yet been completely degassed, such as hydrocarbons and petroleum products.

There are various types of tanks, commonly called floating-roof tanks, in which the surface of the stored, vapor-emitting liquid is protected from the surrounding environment by a floating screen whose edges are connected to the inside walls of the tank by a sheet of flexible, gas-impermeable material. The surface of the sheet is sufficient to permit more or less large variations in the level of the stored liquid while still guaranteeing complete separation of the liquid and of the tank capacity above the separation level. The walls of the tank consist of sheet metal. This storage system has so far been used only for relatively small volumes, i.e., considerably less than one million m^3 of liquid products because of the very high cost of metal tanks with very large dimensions.

There are also very large capacity tanks, consisting of natural or man-made excavations whose walls are made impermeable either by cementing and lining with asphalt, or by covering the liquid levels with plastic substances. The impossibility of making cheap covering layers which would also be completely tight with respect to hydrocarbons or other petroleum products, while still retaining sufficiently strong mechanical resistance qualities, has led to the storage of oil under a layer of water. Although this solution does offer some advantages, it has a number of drawbacks. These drawbacks include a by no means negligible loss of storage capacity volume, control of water supply and oil supply, and, above all, difficulty in making a sufficiently tight roof by virtue of the variations in the level of the surface of the stored liquid.

To solve this problem, one solution consisted in keeping the level of the roof constant, which entailed new drawbacks in terms of the water and oil supply without resolving the difficulty of getting a roof that would be perfectly tight with respect to the petroleum products.

One might also think of using a roof that would not be in contact with the stored liquid, as is done in covering the vast reservoirs of water or brine. But, the constant presence of vapors released by the petroleum products does not make it possible to eliminate the initial difficulty of making cheap roofs with good mechanical resistance qualities and roofs which would be impermeable to the vapors released by the petroleum products.

SUMMARY OF THE INVENTION

The main purpose of this invention is a storage tank for volatile liquid products, especially petroleum products, characterized by the fact that it involves the following: (a) A roof made up of at least one relatively gas impermeable sheet in contact with the surface of the stored liquid and an upper water-impermeable envelope, (b) A lower envelope that is impermeable to water and to the hydrocarbons in contact with the walls of a natural or manmade cavity, said envelope being connected along its edges to the edges of said relatively impermeable sheet; (c) A first anchoring ring attaching

the edges of the lower envelope and the sheet to the edges of the natural or manmade cavity; (d) A second anchoring ring, outside the first one, for the attachment of the edges of said upper envelope and; (e) A series of fans which inject a flow of air between the upper envelope and the sheet for inflating the envelope and applying the sheet against the stored liquid, the level of said first ring being above the water flowoff surface and the inflated envelope including at least one opening arranged opposite the air flow injection.

Such a tank offers a considerable improvement when compared to solutions recommended so far, for the following reasons:

While completely protecting the floating sheet from any outside pollution, the inflated roof makes it possible, by virtue of the overpressure, created between the upper envelope of the roof and the floating sheet, in contact with the liquid surface, to obtain a uniform composition of the crude petroleum product, which so far could be obtained only by determining the weight of the metallic floating roofs, a solution which is impossible when we must build cheap but very large-capacity tanks.

The combination thus achieved involves the creation of a protective shell consisting of the permanent air flow above the sheet, which makes it possible to maintain excellent isothermal protection through the introduction of a cold or hot air flow, as may be required.

Furthermore, this combination makes it possible to prevent any risk of gas accumulation which would in turn involve the risk of creating an explosive mixture between the upper envelope and the floating sheet.

It is therefore no longer necessary to select, as the floating roof, a sheet that will be strictly impermeable to the vapors of the petroleum products since the introduction of the mixture of blown air and degassed products, at a specific point along the external envelope, furthermore permits easy control of the installation, thus helping to quarantee complete and economical protection of the installation.

Another object of the invention is a reservoir with a capacity greater than 200,000 tons in which the portion of the roof, constituted by the sheet in contact with the stored liquid, is supported by a series of floats, distributed over the surface of the liquid.

The presence of floats supporting the separation sheet between the air and the liquid makes it possible to use a sheet material whose mechanical resistance characteristics are less than those required for sheets whose floats had to support, in addition to the weight of the sheet, the weight of a supplementary water layer used to guarantee the hermetic nature of the floating roof, said weight being considerably greater than the forces created by the overpressure required for the inflating of the upper portion of the roof, said overpressure varying at most between 4 and 12 g/cm^2.

It is therefore possible to use as the envelope for the upper portion of the roof a polyvinylchloride and as a floating sheet, some nitrile rubber, on a polyester screen.

Moreover, this arrangement enables us to obtain a sufficiently large air volume so that, regardless of the escape from the floating level and consequently the degassing speed of the stored petroleum liquid, the concentration of the mixture of air and combustible vapors will never attain a harmful value. The importance of this special feature of the invention is that it avoids, si-

multaneously, the use of a strictly hermetic material as the upper portion of the roof and the employment of a strictly hermetic connection of the edges. The air flow is thus made up primarily of a current that sweeps from one end of the air mass to the other, that is, the air mass between the floating sheet and the upper portion of the roof, as well as by series of more or less diffuse and low-intensity branches.

Another object of the invention is a tank of the type described with a trapezoidal cross section whose floating roof portion is made up of a relatively gas-proof sheet which is impermeable to hydrocarbons and to other petroleum products resting on an assembly of floats distributed in alignment parallel to their length, itself parallel to the larger dimension of the tank, and in transverse rows, said sheet being attached to each of the floats situated perpendicularly with respect to the lateral walls of the tanks, a pair of cables with length equal to the length of the inclined side of the transverse cross section being anchored on the ring that externally borders on the line connecting the sheet to the external envelope of the walls of the tank, said cables connecting the ends of said floats belonging to one and the same transverse row, so that, when the tank empties, the pair of cables alone supports the float adjacent to the ring and the weight of the adjoining portion of the sheet, then the weight of the second float and of the part of the sheet corresponding to it, and so forth and so on, while the central portion of the sheet, still resting on the floats supported by the storage liquid, does not undergo any major traction effort.

The advantage of this combination is that it gives a simple and cheap tank because, contrary to the already known floating roofs, which require complex assemblies to take into account the variation in the surface of the roof with the level of the liquid stored, it suffices to use a simple assembly of floats on which rests a flexible sheet that is not subjected to any major traction. It is clear that such a solution may be carried out in many variations.

Thus, the interval between the floats situated perpendicularly with respect to the horizontal portion of the bottom of the tank may be obtained by simple light and rigid elements, which may be hollow for example, also serving as support for the sheet. Only the portions of the sheet near the edge of the tank may present folds, but this does not entail any inconvenience because the sheet constantly assures the separation of the air from the liquid and cannot suffer any damage when the liquid level drops, as we have just explained.

Another object of the invention is a tank where the inflated envelope of the roof is reinforced by a series of transverse and taut cables, anchored in the ground at each of their ends, each of them being connected to the envelope at least three points with the help of attachments.

In accordance with the teaching of this invention, the capacity of the existing tanks can be increased considerably, up to and beyond one million tons, since resistance to wind becomes sufficient to prevent any exaggerated deformation or to prevent the inflated roof from being ripped off. Furthermore, under the combined action of cable tension and overpressure prevailing between the floating part of the roof and the upper envelope, grooves are formed outside the envelope facilitating the flowoff of rain water.

Another object of the invention is a tank in which said first and second rings are part of one and the same cast-concrete slab at the summit of the natural talus, obtained during the digging of the excavation whose walls, along with those of the talus, constitute the cavity against which rests said lower envelope, said slab involving, outside the second anchoring ring, a groove for channeling the runoff water and, internally, a second groove constituting said first anchoring ring, the second ring being made up of standby irons, ready for the anchoring of said upper envelope.

Another object of the invention is a tank of this type, where the outside surface of the lower envelope is provided with a waterproof coating and where the terrain surrounding said walls is provided with water drainage pipes, the inside surface of the envelope being covered with a sheet of PVC or polyamide, commercially known under the name of Rilsan, or nitrile rubber, the edge of said sheet, which is impermeable to the petroleum products, being connected with the edge of the floating roof, the assembly of the superposed edges of the sheet and of the floating roof being embedded in the upper portion of the wall of the tank cavity.

In this way we get a tank with a capacity considerably greater than that of the present tanks, while involving a relatively low cost in spite of its qualities of tightness and its protection against any risk of formation of explosive mixtures of vapors from petroleum products.

Another object of the invention consists in a tank of this type where the sheet, which is impermeable to the hydrocarbons, is made from the superposition of two sheets, one thin layer of sand, with a thickness of between 5 and 50 cm, resting over the entire inside surface of the sheet applied to the bottom of the tank.

This arrangement offers the advantage of making possible the detection of any escape of liquid in [into] the upper portion of the sheet, because the liquid infiltrates through the sand until it gets to a detection instrument.

Another object of the invention is a tank of the above-mentioned type, where the lower envelope, impermeable to water and to hydrocarbons, is made up of a compacted clay layer, resting on the walls of the cavity, said layer being mixed with any fungicidal product and keeping away burrowing animals, such as Borax, with a sheet impermeable to the petroleum products resting on said layer.

It thus becomes easy to build vast tanks at a very low cost and without having to cement the excavation whose fill would serve to constitute talus intended, on the one hand, to increase the capacity of the tank, and, on the other hand, to anchor the floating roof and the sheet which is impermeable to hydrocarbons.

Another object of the invention is a tank of the above-mentioned type where the waterproof envelope is made up of a first sheet of polyamide known under the name of Rilsan, whose one face rests directly on the surface of the ground and whose opposite face is in contact with a sheet impermeable to hydrocarbon.

Other objects and features of the invention will emerge from the following description given here with reference to the attached drawing which, by way of nonrestrictive example, presents one way of making a tank with a large capacity and a variable level.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a lateral elevation view of a tank, taken here

by way of example, and in accordance with invention;

FIG. 2 is a plan view of this tank;

FIG. 3 is a view of the cross section made along the line III—III of FIG. 1;

FIG. 4 is a detail of the cross section view IV—IV in FIG. 2, showing the connection of the roof to the concrete slab surrounding the reservoir in a longitudinal cross section of the reservoir;

FIG. 5 is an enlarged view of the portion of cross section V—V in FIG. 1, showing the connection of the inflated roof;

FIG. 6 is a variation of the manner of connection shown in FIG. 5;

FIG. 7 is a side view of the tank after the roof has been pulled off, and

FIG. 8 is a partial transverse cross section of a second manner of making the tank.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawing in FIGS. 1 and 2, we introduce the cutting lines 1 to indicate that, contrary to existing tanks, the tank shown may, by virtue of the features of the invention, attain very vast dimensions without involving any increased cost of material utilized which remains only proportional for a given width to the length of the tank. We thus benefit from this fact so as to be able to make the facility with a width on the order of 50–200 m, for example, while the length would be several hundred meters.

The broken line 2 shows the longitudinal outline of the bottom of the reservoir and line 3 (FIG. 2) shows the outline of the excavation.

The external roof has the shape of an inflated tank 4 (FIG. 1) reinforced by cables, such as 5, attached to a concrete slab 6, forming a ring around the tank.

A set of blowers 7, equipped with several fans, sends the air under the roof 4 through the duct 8. Openings for the evacuation of the blown air, which may possibly be charged with vapors and gases that might have separated from the products stored, are provided in places such as 9 at the end of the roof.

The lines 10 are the connection of the extremities of elements serving for the fabrication of the roof.

In FIG. 2 we again find these various elements, as well as a channel 11, surrounding the concrete slab 6, for the purpose of channeling the runoff water.

The cut along III—III in FIG. 1, is shown in FIG. 3 and shows the inflated roof 4 as well as one of the reinforcing cables 5 which, in the example chosen, is inside the enclosure. The internal roof or the floating roof 12 is supported by lines of floats 13.

In the version shown, the floats 13 of one and the same transverse row are connected by cables, such as 42, so that two consecutive floats cannot, at any moment, move away from each other beyond a given length which itself is less than the length of the sheet portion 12 connecting two consecutive floats. Cables 42 are anchored on the internal circumference of the concrete ring 6 in the proximity of the connection point of sheet 12. The length of each cable 42 is equal to the perimeter of the section of the tank so that, when the liquid level drops, the first lines of floats near the lateral walls will begin to rest on the lateral walls without any traction effort being exerted on the sheet, with the exception of a slight traction from the weight of the portion of the sheet extending between the first float and its point of connection to ring 6. We see that, if we take care to attach the sheet to the floats and to make sure that the liquid level continues to drop until the floats of the second lines near the edge of the tank come to rest on the lateral walls, only the portions of the sheet included between the first and second lines of floats are subjected to a slight traction caused by the weight of the portions considered. It is therefore no longer necessary for the sheet to have very great traction resistance.

When the bottom of the reservoir is horizontal, as in the case in FIG. 7, each cable 42 can be replaced by two cables whose lengths are equal to the small side of the cross section of the reservoir. For each portion of transverse floats in the vicinity of a bank we thus provide one pair of short cables, each cable connecting one of the ends of said floats. The floats that are perpendicular with respect to the horizontal portion of the bottom may be kept away from each other with the help of rigid and light elements, for example, hollow pipes, on which rests the central portion of the sheet.

In the version shown in FIG. 3, we have used drainage pipes 14, connected to the central collector 15. A sheet 16, resting on the clay layer 17, assures the liquid tightness with respect to the ground. This sheet may be a layer of PVC or a sheet of chlorosulfo polyethylene.

The upper envelope of the roof 4 consists of a synthetic screen having good dimensional stability and good rupture resistance, such as the polyamide known under the name of Nylon or the polyester known under the name of Tergal, and is coated by a plastic or elastic material, such as PVC or a chlorosulfo polyethylene, such as the one known under the name of Hypalon.

In view of the vast dimensions of the roof 4, it is assembled by elements whose connections 10 (FIG. 1) are accomplished by gluing, welding, or any other suitable means.

One way of connecting the roof 4 to the concrete slab 6 can be seen in FIG. 4. The sheet metal 43 is sealed in the slab. The roof 4 is inserted between a junction plate 18 and a junction 19, carried by sheet metal 43. Tightening is provided by a bolt 20 passing through eyelet 21.

This arrangement, which we encounter once again over the entire circumference of the tank, constitutes an effective means for perfecting the tightness of the connection of the roof of the tank in cases where we wish strictly to channel all of the blown air flow at very specific points at the extremity of the tank.

FIG. 5 shows details of a similar method of entering which we can use when we already have an existing cavity. On the edges of the cavity, we pour a concrete slab 6, reinforced by reinforced-concrete ribs 6*a*, using as anchoring masses. This slab also receives the attachment devices 18–20 of the tank.

A channel 11 is provided for the flow of the water and a second channel 38 serves to guarantee the tightness of the various sheets 35, 37 and 41 whose role will be explained later. Tightness is assured by introducing these sheets against the walls of the ditch and by packing in here a filling, as shown at 39.

By way of variation, FIG. 6 shows the details of the anchoring arrangement when the excavated material obtained during the digging of the reservoir is accumulated on the edges in order to increase the capacity of the reservoir. Concrete plates 22, which have previously been placed upon the surface of the ground 23, are again covered by rubble 24. Metal rods 25, sealed

in plate 22, are flush with the surface of the filling and cross the cleaning walkway 27 through tubes 28.

The channel 11 serves for the flow of rainwater and channel 26 serves to assure the tightness of sheets 46 and 47.

In the case considered here, sheet 46 is an inexpensive sheet such as a simple sheet of PVC with a polyester weft, offering only those mechanical qualities which will be sufficient to prevent the sheet from becoming deformed under a weight of 2 t/m and mediocre tightness qualities with respect to the vapors coming from the petroleum products. On the other hand, the sheet 47 is a complex sheet whose base resting on the ground offers excellent qualities of resistance to perforation and to traction. This face may also be made of PVC or of a chlorosulfo polyethylene, such as it is known under the name of Hypalon. The inside face of the sheet furthermore presents excellent characteristics of chemical resistance and is perfectly tight with respect to hydrocarbons. If the outside face is not impermeable to water, we coat this face with a layer of paint made from a chlorosulfo polyethylene, such as the one known under the name of Hypalon, so that we obtain an external envelope capable of resisting strong mechanical efforts while still being imputrescible.

In order to make the drawing of the tank protected by the inflated roof clearer, we have shown in FIG. 7, the side view of the tank whose roof has been retracted and, in FIG. 8, we have an enlarged cross section of the wall of a tank with a triangular transvere cross section.

In FIG. 7, between lines 31 and 32, we have shown a portion of the bottom of the tank 33 with a trapezoidal cross section. The slopes 34 are the natural slopes obtained during terracing and after compacting of the soil. Above this surface, which may have been drained and completed by a cover of clay with a thickness of 10–30 cm, shown at 48 in FIG. 8, and possibly a fine layer of sand 49, we arranged a first sheet 35. This sheet may be made up by the assembly — by means of welding or gluing — of sheets of plastic or elastic materials, such as PVC or a chlorosulfo polyethylene, such as the one known under the name of Hypalon.

Above the sheet 35, FIG. 7, we possibly arrange a thin layer of sand 36 whose thickness may vary between 5 and 40 cm and which we cover with a second layer 37 in direct contact with the products stored. This sheet, whose characteristics may be similar to those of sheet 47 in FIG. 6, is made by the assembly, by means of welding or gluing, of sheets of plastic or elastic materials, such as PVC and possibly of the same kind as sheet 35 when we selected a PVC for it.

The lateral edges of these two sheets overlap on the surfaces of slopes 34 and end in the ditch 38 whose bottom and walls they cover.

The arrangement of these sheets in ditch 38 is furthermore visible in FIG. 5 where we have also shown a packed filling 39 which makes it possible to retain the sheets in position.

The liquid stored, shown at 40, is introduced between the sheet 37 and a sheet 41 which may be of the same kind as sheet 37, provided the latter has a certain dimensional stability. This sheet rests partly on the lines of floats 13 represented in FIG. 3. The end of the sheet 41 is retained, as sheets 35 and 37, by the packed filling shown at 39, FIG. 5. The liquid is introduced through a pipeline which we put in any suitable place. By way of example, we can have the liquid pipeline come out through an opening 53 made in the sheets 35 and 37, with the pipeline running under the ditch 38. We make the junction of the pipeline and sheets 35 and 37 tight by any suitable means, for example, with the help of a flexible sleeve 51 (FIG. 8) welded upon sheets 35 and 37 and attached to the pipe 50 by a collar 52 with sealing joint.

By way of variation we can also directly run the pipeline between the sheet 37 and 41 without making an opening in the lower sheets; this arrangement eliminates certain problems of tightness.

It is clear that we can arrange any number of liquid pipelines and tap lines.

One particularly simple way of building the tank consists in improving a natural cavity or creating an aritificial cavity, forming a straight and regular trench whose cross section may be any form whatsoever, compacting the earth constituting the bottom, the walls, and the banks of the reservoir, surrounding the cavity with a ditch, pouring a concrete slab surrounding said ditch be sealing into it the means for the attachment of a joint and means of anchoring for the placement of the cables, applying on the land delimiting the cavity a layer of clay, laying down the lower sheet and then the layer of sand and then the two other sheets, making the passages necessary for the inlet and outlet conduits for the liquid, as well as passages for the apparatus used in detecting escape of liquid into the sand. It then suffices to attach the elements of the cistern to the joints provided on the concrete slab and to attach the cables to their anchoring in order to obtain a reservoir ready to operate. We inflate the cistern by means of the blowers 7 and we can introduce the liquid to be stored.

The small openings 9, FIGS. 1 and 2, enable us constantly to renew the air, which is more or less charged with vapors, by possibly filtering through the sheet 41. In this way we prevent the creation of any explosive mixture.

Although we have described only one way of making a reservoir in accordance with the invention here, as well as only one of its variations, it is clear that we would not be going beyond the framework of the invention if we were to replace the various means used by equivalent means.

What is claimed is:

1. A storage reservoir for storing volatile liguids formed from a natural or man-made cavity comprising:
   a. a floating roof, positioned over and in contact with the surface of the stored liquid,
   b. an inflatable roof spaced from and positioned over said floating roof, said inflatable roof containing at least one opening to permit evacuation of gases collected between said floating and inflatable roofs,
   c. a series of cables reinforcing said inflatable roof, said cables being anchored in the ground at each of their ends, and
   d. a series of fans for injecting an air flow between said floating and inflatable roofs to inflate said inflatable roof, force said floating roof into contact with the stored liquid and aid in the evacuation of collected gases through said at least one opening.

2. The storage reservoir of claim 1 further including a water and gas impermeable layer lining said cavity, a first anchoring ring formed around the circumference of said cavity and a second anchoring ring positioned

outside said first anchoring ring with respect to the cavity for anchoring said inflatable roof.

3. The storage reservoir of claim **2** further including floats distributed over the surface of the liquid for supporting said floating roof on the surface of the liquid.

4. The storage reservoir of claim **3** wherein said floating proof is comprised of material substantially gas tight and impermeable to hydrocarbons, said floats being placed in a series of rows parallel to the width of the cavity, further including at least one cable per row of floats interconnecting the floats in each row, said cables being coupled to said cavity by said first anchoring ring, said cables being of a length such that the length of cable coupled to a row of floats at least equals the sum of the lengths of the sides of the cavity to which the cables are coupled and its base, the interval of cables between consecutive floats being less than the lengths of the corresponding parts of the floating roof included between their points of attachment to two consecutive floats.

5. The storage reservoir of claim **4** wherein said cavity has sloped walls, said first and second anchoring rings being formed in a single concrete slab formed at the summit of the sloping walls, said first anchoring ring being comprised of a first channel surrounding said cavity said slab further including a second channel for channeling runoff waters from said inflatable roof.

6. The storage reservoir of claim **4** further including anchor plates for anchoring said series of cables for reinforcing said inflatable roof said anchor plates being arranged at ground level and covered by excavated earth removed from the earth to form the cavity.

7. The storage reservoir of claim **5,** further including water drainage conduits positioned in the ground surrounding the walls of said cavity and a layer of PVC or polyamide covering the internal surface of said inflatable roof the edge of said layer of PVC or polyamide being connected to said floating roof.

8. The storage reservoir of claim **7,** wherein said layer lining the cavity includes 0.5–40 cm layer of sand.

9. The storage reservoir of claim **8,** wherein said layer lining the cavity further includes a layer of compacted clay resting on the walls of the cavity, said layer being mixed with any fungicidal product to keep burrowing animals away.

10. The storage reservoir of claim **9,** wherein said layer of sand is situated directly above said layer of clay.

11. The storage reservoir of claim **1** wherein said inflatable roof comprises a plurality of joined sections of flexable material, each of said sections being supported by a reinforcing cable anchored in the ground at each end.

12. The storage reservoir of claim **11,** further including a water and gas impermeable layer lining said cavity and comprising a layer of compacted clay resting on the walls and base of the cavity, said layer of clay being mixed with a fungicidal product for keeping burrowing animals away from the stored liquid, a first layer of sand formed over said layer of clay, a first layer of liquid tight material formed over said first layer of sand, a second layer of sand formed over said first layer of liquid tight material and a second layer of liquid tight material formed over said second layer of sand and in contact with the stored liquid.

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