(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 903 304 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.03.1999 Bulletin 1999/12

(51) Int. Cl.[6]: **B65D 90/00**, B65D 90/04

(21) Application number: **98117736.3**

(22) Date of filing: **16.09.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **18.09.1997 EP 97116242**

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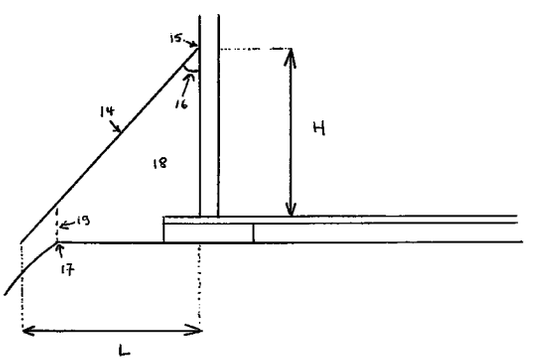
(54) Protection of large above-ground storage tanks against corrosion

(57) The present invention discloses a method for protecting against external corrosion the bottom part of storage tanks (2) which have a diameter larger than 20 metres, by fitting a waterproof skirt (14) around the bottom part of the tank, said skirt (14) being designed to simultaneously suppress water infiltration by adequate insulation and eliminate condensation water by adequate ventilation.

Figure 3



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Description

[0001] This invention relates to a method for protecting above-ground storage tanks against external corrosion.

[0002] The background and the invention are described with the help of the following Figures:

- Figure 1 represents the main features of large storage tanks;
- Figure 2 represents the undesired deformation of the ground caused by the weight of storage tanks and their contents;
- Figure 3 represents a waterproof skirt according to the present invention;
- Figure 4 represents a preferred embodiment of the present invention;
- Figure 5 represents an embodiment of a window useful with the preferred embodiment of Figure 4;
- Figure 6 represents an optional drainage trough dug around the foot of the storage tank in order to collect water.
- Figure 7 represents an inspection window.

Background.

[0003] Large storage tanks can have a diameter of up to about 88 m and the weight of their content can reach up to 100,000 tons. Referring to Figure 1, they comprise as bottom part an horizontal annular metal ring (1) which has a mean diameter of about 88 m, a width of 30 to 50 cm and a thickness of 10 to 13 mm. Upon this ring (1) are welded horizontal metal sheets (2) of a thickness ranging from 6 to 7 mm. This horizontal structure (1,2) is surmounted by the vertical metal walls (3) of the tank which are made of a series of cylindrical shells welded on top of one another, each having a height of 1.5 to 2.5 m and a thickness which decreases from about 32 mm for the lowermost shell to about 6 mm for the uppermost shell; the total height of the tank is about 21 metres. The lowermost cylindrical vertical wall is welded to the horizontal ring (1) by a welding seam (26).

[0004] These tanks are equipped with an internal floating roof (4) which is made of a metal sheet, about 5 mm thick, weighs about 350 tons and is equipped with up to 200 legs (5) which, under operating conditions, are set at a height under the roof of 1.5 m and, under maintenance conditions, at a height under the roof of 2 m. This roof (4) serves several purposes: it is used to prevent vapours and gases from escaping the tank, to protect the stored fluid from external contamination and to determine the fluid level in the tank. It is equipped with safety devices to allow prompt intervention in case of fire hazard. It also contains a system (6) for collecting and evacuating rain water which would otherwise accumulate on top of the roof (4) and cause it to sink; the water is evacuated through a pipe which is made of three or more segments (7) articulated with respect to one another (8) in order to adjust to the changing height of the roof.

[0005] The tanks are filled and emptied through a pipe (9) which has a diameter of about 90 cm and allows a flow rate of about 16000 m^3 per hour. The input flow can automatically be interrupted when the roof has nearly risen to the top of the tank.

[0006] Because of their enormous weight, when filled, these large tanks are built upon a basement (10) constituted of sand and gravel. Such basement (10) typically has a diameter which is about 3 metres larger than the diameter of the storage tank and a height of about 1 metre above the ground. It is covered with a waterproof layer of bitumen which has a thickness of about 10 cm.

[0007] As the weight of the stored oil varies from 0 when empty to up to 100,000 tons when full, the platform undergoes deformations when the level of the fluid in the tank is modified. It flattens when the tank is filled and rebounds when the tank is emptied; this deformation can reach up to 3 cm. The tank itself undergoes an horizontal deformation of up to about 8 cm for a full tank of 88 m diameter. These changes can be considered as essentially reversible.

[0008] Referring to Figure 2, it is observed, however, that in addition to the predicted flattening of the platform and expansion of the tank, an undesired local deformation also occurs at the edge (11) of the metal annular ring (1) of the storage tank. A bulge (12) is formed and it increases with each successive deformation upon loading and downloading of the tank. This bulge allows water to seep and infiltrate (13) between the bitumen covered platform (10) and the metal bottom (1,2) of the tank, thereby allowing corrosion of the metal sheets (2) forming the bottom (1,2) of the storage tank. As air is also allowed to penetrate at the same time as water, at least under the outer part of the tank, corrosion is observed in the outer part of the tank floor over a distance of about 3 m. Because corrosion of the tank's bottom may lead to leaks and therefore pollution of the underground, the welding seams and metal sheets forming the floor of the large storage tanks must be inspected at regular intervals (e.g. every 10 years). The tank's floor can only be accessed

through the tank interior; this therefore requires that the tank be completely emptied and gas-free for inspection.

[0009] It is an object of the present invention to solve the problem of corrosion of the metal floor of above-ground large storage tanks.

[0010] It is another object of the present invention to increase the time between two consecutive inspections of the welding seams and bottom of the tanks.

Summary of the invention.

[0011] The present invention discloses a method for protecting against external corrosion the lower part of storage tanks which have a diameter larger than 20 metres and preferably larger than 40 m.

[0012] It is now found that corrosion can be prevented from seeping underneath the floor of large storage tanks by placing a downwardly extending waterproof skirt around the bottom part of the tank, said skirt being designed to create a ventilated space limited by the vertical wall of the tank, the horizontal floor of the platform and the skirt.

Detailed description of the invention.

[0013] The invention is best described by way of specific embodiments, without wanting however to limit its scope to these embodiments alone.

[0014] According to a preferred embodiment of the present invention, the waterproof skirt (14) fitted around the exterior bottom part of the tank is a flexible membrane made of polypropylene sheets. Referring to Figure 4, the upper end of the skirt (14) is glued to the vertical wall of the tank at a height of about 60 cm (15) and the inferior end of the skirt is glued to the bitumen of the tank basement (10) at an horizontal distance of about 60 cm from the bottom of the tank (20). The skirt (14) is allowed a small amount of curvature between these two fixed points (15,20) in order to accomodate for the lateral motions of the tank's wall and the vertical motion of the tank basement when the tank is filled or emptied.

[0015] Ventilation is obtained through "windows" or openings (21). Referring to Figure 5, these openings are properly screened by a fine flexible mesh (22) in order to avoid the undesired entrance of vermin (rodents or insects) or waste, and covered by an awning in order to avoid water infiltration (23). Such windows are typically spaced between 10 and 15 m.

[0016] Referring to Figure 6, a prior art embodiment was designed to solve the problem of corrosion by digging a drainage trough (24) around the edge of the metal ring (1) supporting the bottom of the tank (2), in order to collect rain water. It was observed however that the upward and downward motion of the tank at unloadindg or loading did create a small additional bulge (25), thereby reducing but not suppressing the problem of corrosion. A waterproof skirt (not represented) must therefore also be fitted around the bottom of the storage tank, but in addition to the above-described embodiment of the present invention, it is necessary to dig narrow evacuation troughs (not represented), about perpendicular to the drainage trough, at regular intervals (e.g. every 25m) in order to drain any water collected in the drainage trough. These evacuation troughs are each screened by a stainless steel mesh which is tightly fitted to the bottom of the trough at the lower end and glued to the bottom of the waterproof skirt at the upper end.

[0017] It is preferably desired that the important welding seam(26) between the vertical walls (3) of the tank and the horizontal metal ring (1), be easily accessed for inspection. For this purpose, refastenable openings can be carved in the skirt (14) where necessary.

[0018] According to a preferred embodiment of the present invention, the awning (23) is mobile and can be opened and fastened with refastenable closing means; it is opened when inspection is desired (see Figure 7) and, under operating conditions, it remains in a semi-open position thereby allowing moisture out and no water in.

[0019] Referring to Figure 3, in yet another embodiment of the present invention, the skirt (14) is fitted to the vertical wall of the metal tank by a watertight seal (15) at a height ranging from 30 to 100 cm from the ground, downwardly extends, without touching the ground, to a lateral distance which goes beyond the edge (17) of the platform (10), defined here as the point where the platform floor starts sloping down, and makes an angle (16) with the vertical wall of the tank defined as $\tan^{-1}(L/H)$ where L is the horizontal distance between the vertical wall of the tank and the edge of the platform increased by at most 15 cm, and H is the height above the tank's floor at which the skirt is attached to the vertical wall of the tank. The above-described set up creates a dry and ventilated space (18) limited by the vertical wall (3) of the tank, the horizontal floor (27) of the platform and the skirt (14); this space is screened (19) to avoid entrance of vermin or waste. The skirt is manufactured either by using a rigid material or by using a semi-flexible material maintained in an open position by means of rigid elements placed at regular intervals.

[0020] For large storage tanks equipped with the waterproof skirt of this invention, the timespan between two consecutive inspections of the welding seams and floor is now brought up to 20 years.

Example.

[0021] The waterproof skirt fitted around the exterior bottom part of the tank was a flexible membrane made of polypropylene sheets. The upper end of the skirt has been glued to the vertical wall of the tank at a height of about 60 cm and the inferior end of the skirt has been glued to the horizontal floor of the platform at an horizontal distance of about 60 cm from the bottom of the tank. The propylene sheets which have a surface of 1 m by 3m, and a thickness of 2mm were sealed together. They were made of thermoplastic rubber extruded from a compound based on polypropylene; they offered an improved resistance to biodegradation, chemical reactions and UV light. Their properties were quantified as follows.

Temperature range	-40° C (DIN 53361) to +80° C (DIN 53377)
Density	0.9 g/cm^3
Modulus	100 N/mm^2 at 23° C
Maximum elongation, multiaxial	> 150%

Coefficient of linear expansion	0.07 mm per m/° C
Thickness	0.5 to 2 mm
Flame resistance	DIN 4102 B2

[0022] After periodic exposures to rain water and UV light according to ASTM G26, for a total duration of 4000 hour, at a temperature of 80° C, the strength and the extension to breaking point have been evaluated according to ASTM D638.

Sample n° 1	0 hour	2000 hours	4000 hours
Stretching strength	100	100	96
Break by stretching	100	94	78

[0023] In another method according to ASTM G90, the alteration of the material is measured in terms of Langleys. In the Netherlands, 100,000 Langleys correspond to the corrosion observed after one year of exposure to external conditions whereas in tropical situation, 150,000 to 180,000 Langleys correspond to the corrosion observed after the same length of time. In the present Example, carried out in the Netherlands, only minor alterations have been observed in the mechanical and physical properties of the propylene after 2 millions Langleys. This is summarised in the following table.

Sample n° 2	0 hour	1000 kLangleys	2000 kLangleys
Stretching strength	100	112	112
Break by stretching	100	104	98

[0024] The resistance to cracking of the propylene used in the present invention has been tested according to ASTM 1693.

[0025] For the membranes of the present invention, no cracking has been observed to start and spread after 3000 hour of exposure to a soap solution of Igepal concentrate, when measured in the temperature range of 20 to 100° C.

[0026] Ventilation was obtained by cutting rectangular openings about 30 cm high and 20 cm wide in the skirt; these openings were screened by a fine flexible mesh and covered by an awning which was attached to the upper edge of the opening and refastened to a half-closed position with Velcro®, under operating conditions. The openings were placed every 10 m.

Claims

1. Method for protecting against external corrosion the bottom part of storage tanks which have a diameter larger than 20 metres, by placing a downwardly extending waterproof skirt around the bottom part of the tank, said skirt being designed to create a ventilated space limited by the vertical wall of the tank, the horizontal floor of the basement and the skirt.

2. The method of claim 1 for protecting against external corrosion the bottom part of storage tanks which have a diameter larger than 40 metres.

3. The method of claims 1 and 2 wherein the skirt is made of a waterproof flexible membrane which is fitted to the vertical wall of the tank and to the horizontal floor of the platform through waterproof seals and presents screened ventilation openings which are protected from water infiltration by semi-open awnings and which are spaced at regular intervals.

4. The method of claims 1 to 3 which simultaneously allows for inspection of the seal joining the vertical metal walls of the storage tank to its horizontal metal floor through the ventilation openings.

5. The method of claims 1 to 4 wherein the waterproof skirt is made up of propylene sheets sealed together.

6. The method of claims 1 and 2 wherein the skirt is fitted to the vertical wall of the metal tank by a watertight seal at a height ranging from 30 to 100 cm from the ground, downwardly extends to a lateral distance which goes beyond the edge of the platform without touching the ground, creating a dry and ventilated space limited by the vertical wall of the tank, the horizontal floor of the platform and the skirt and which is screened to avoid entrance of vermin or waste.

7. The method of claim 6 wherein the skirt is made of rigid material.

8. The method of claim 6 wherein the skirt is made of semi-flexible material held in open position by means of rigid elements placed at regular intervals.

9. The method of claims 1 to 8 wherein the water collected in the optional drainage trough surrounding the bottom part of the large storage tank is evacuated outside of the area sheltered by the waterproof skirt through drainage troughs about perpendicular to said main drainage trough.

10. Use of the method of claims 1 to 9 for increasing the time separating two consecutive inspections of the seals and floor of large storage tanks

Figure 1

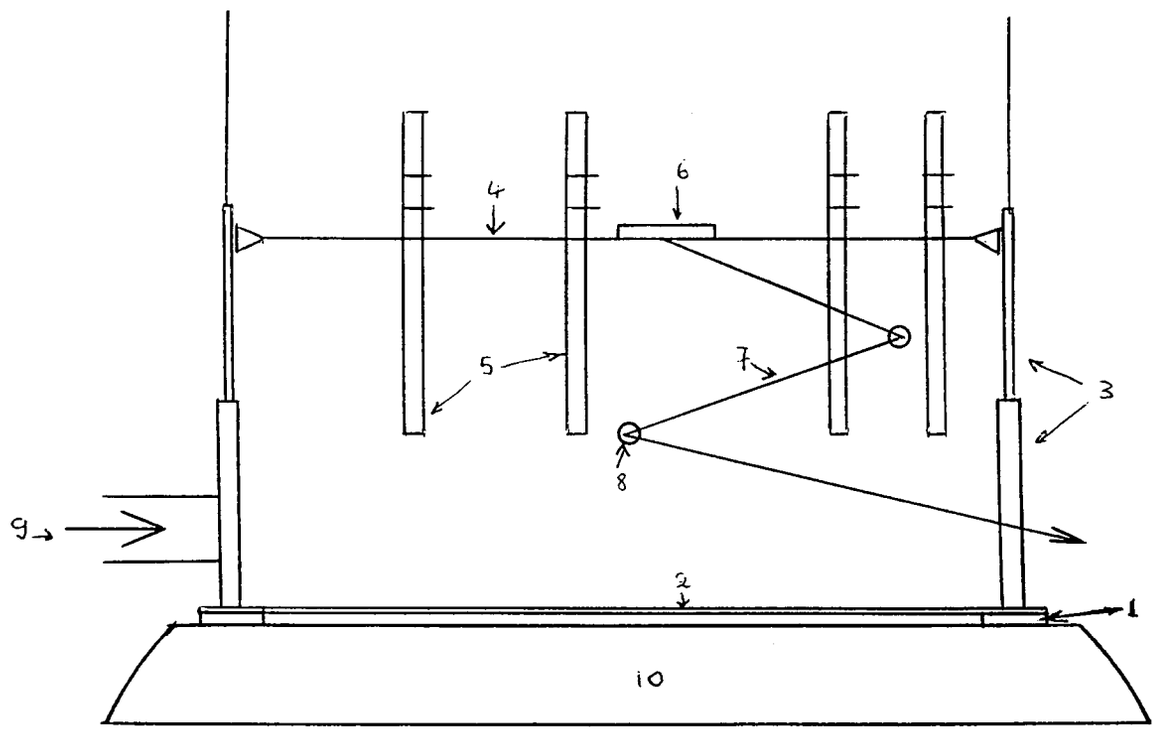
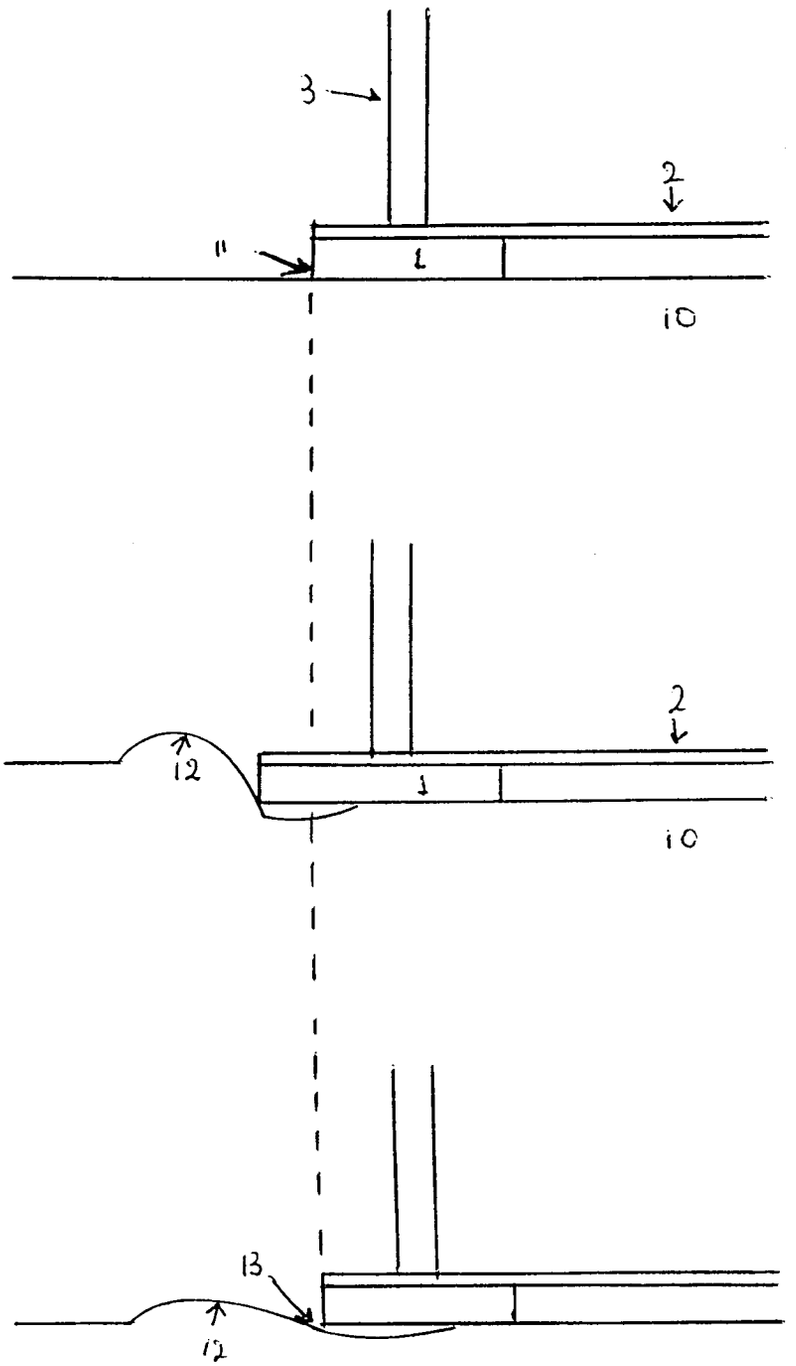


Figure 2



Empty tank

Full tank

Empty tank after Deformation

Figure 3

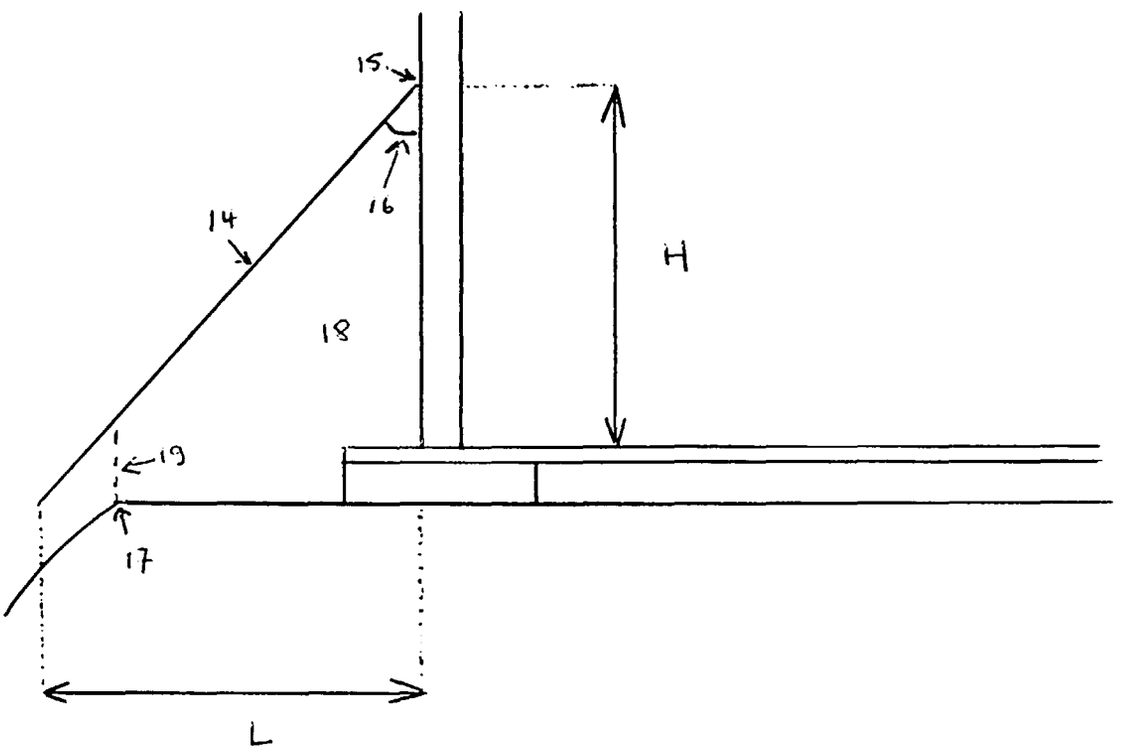


Figure 4

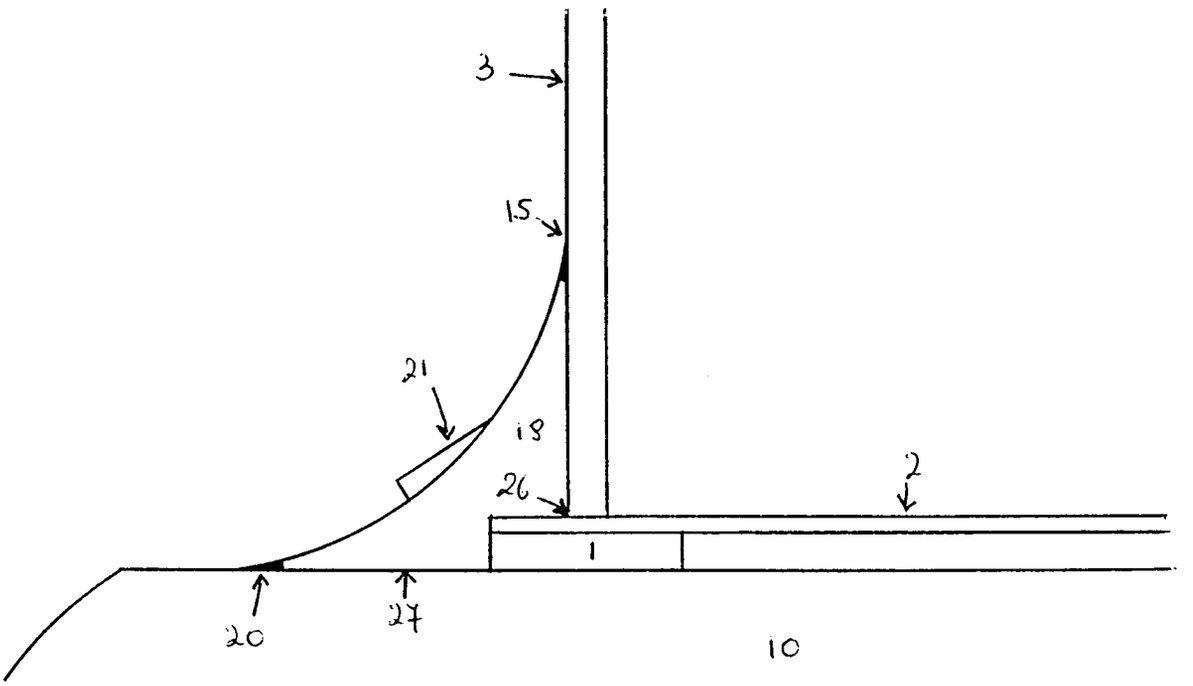


Figure 5

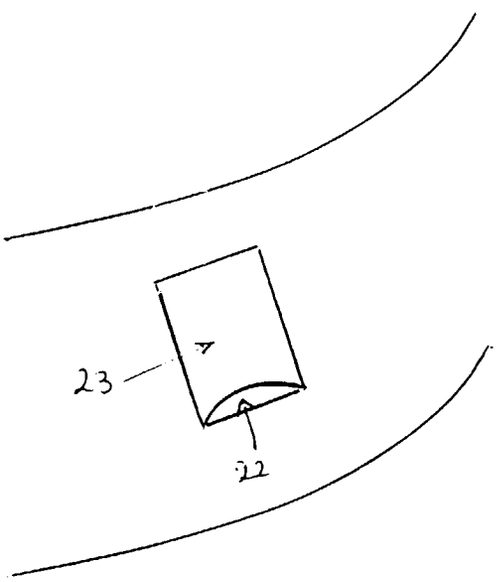


Figure 6

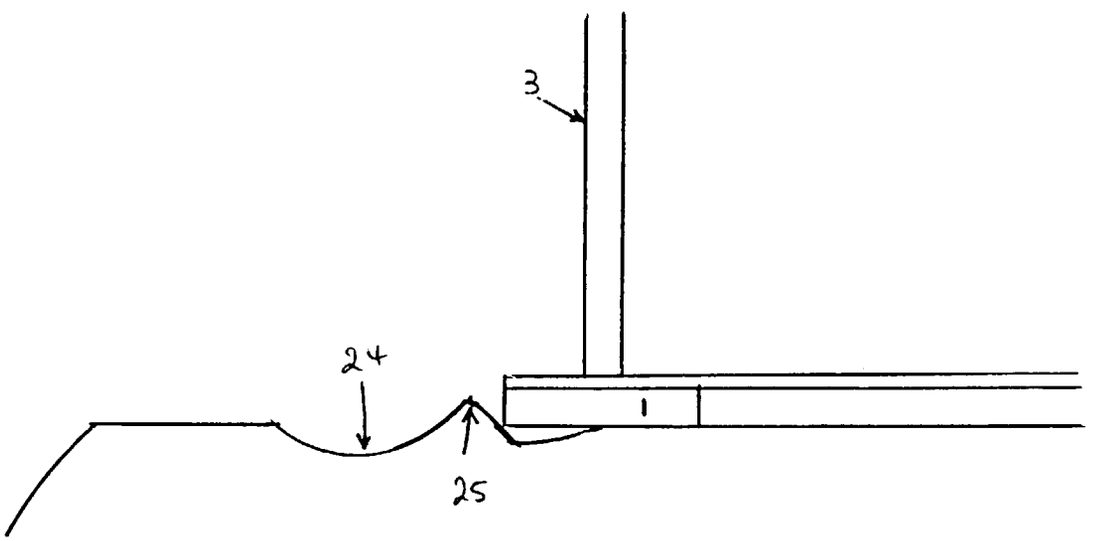
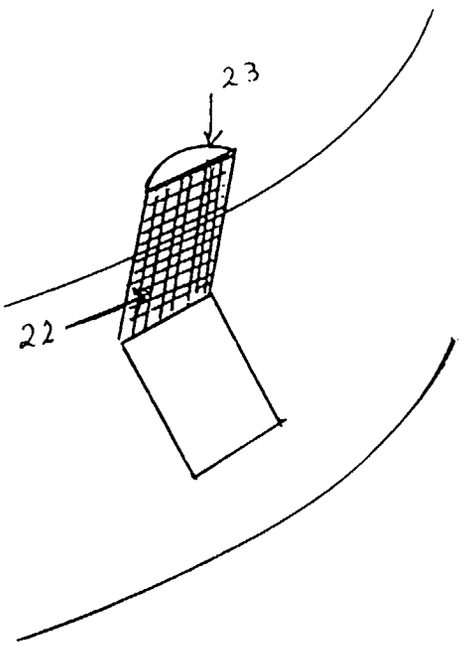


Figure 7



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EUROPEAN SEARCH REPORT

Application Number
EP 98 11 7736

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B65D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 December 1998	Müller, C

CATEGORY OF CITED DOCUMENTS

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