Nov. 24, 1959 A. F. FINO 2,914,212

FLOATING ROOF WEATHER SEAL

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FIG.1

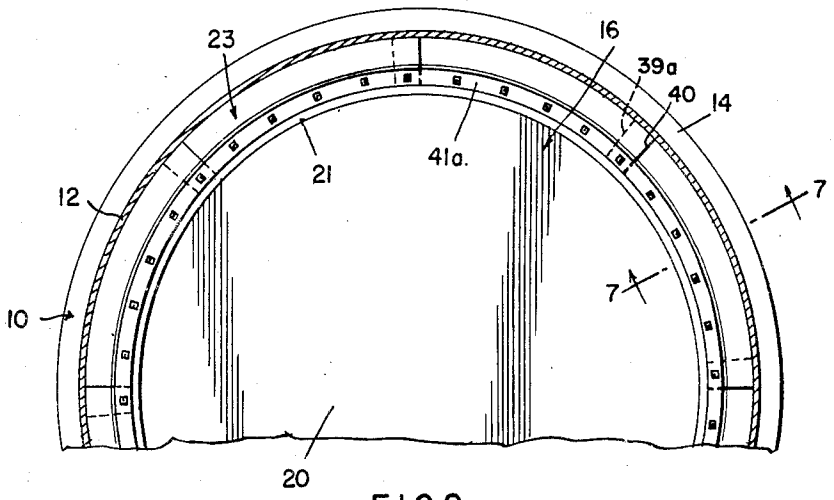


FIG.2

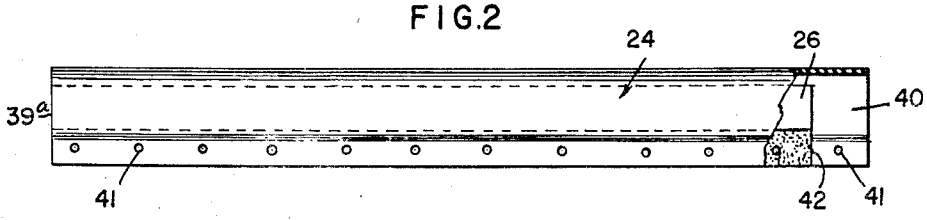


FIG.6

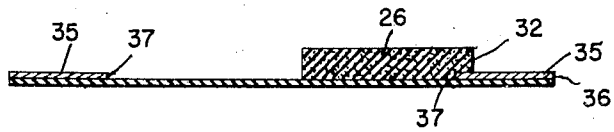
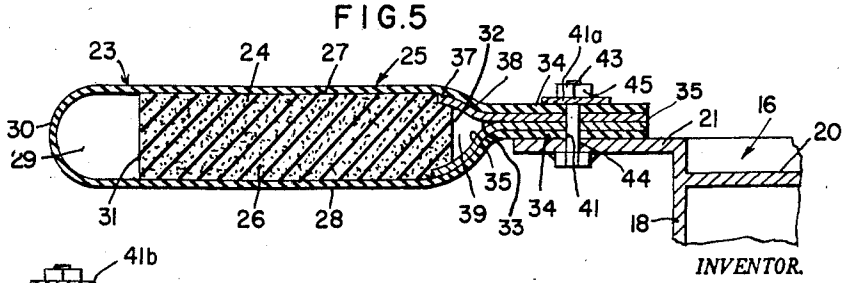


FIG.5



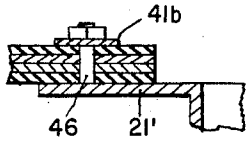


FIG.10

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FIG.3

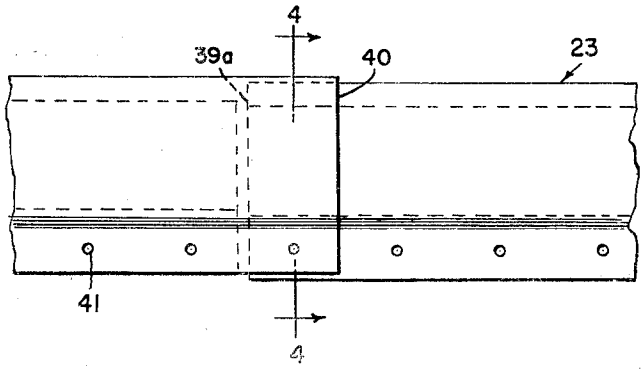


FIG.4

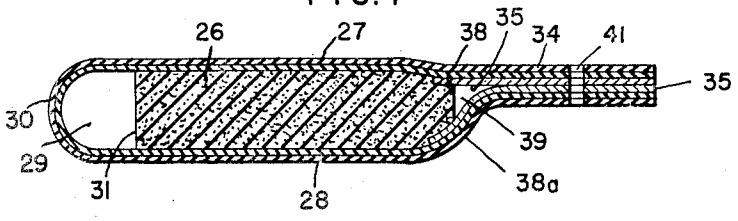


FIG.7

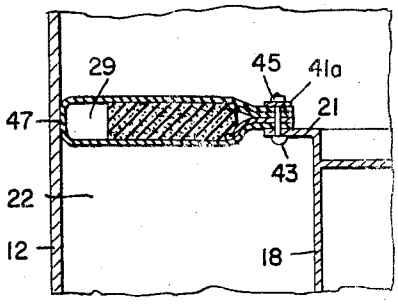
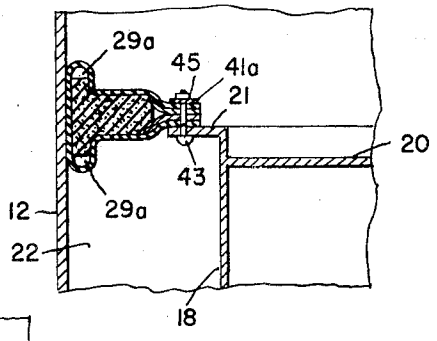


FIG.8



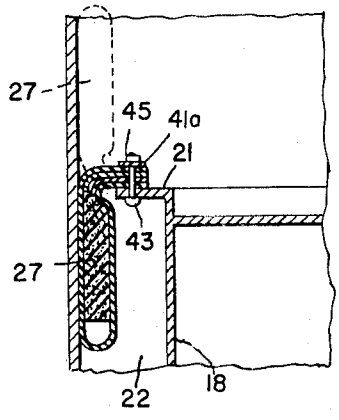


FIG.9

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2,914,212

FLOATING ROOF WEATHER SEAL

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Application August 1, 1957, Serial No. 675,732

3 Claims. (Cl. 220—26)

This invention relates to storage tanks for liquids and particularly to tanks for storing oil and oil products and which tanks are of the type having a roof or cover which floats on the liquid stored in the tank to rise and fall with the level of such liquid.

In tanks of the type referred to, there is the problem of sealing against the weather the space which exists around and between the periphery of the floating roof and the inner periphery of the shell or wall of the tank. It is, accordingly, an object of the present invention to provide, in a manner as hereinafter set forth, a new and improved means for sealing this space which may, if desired, be electrically conducting. Weather seals for closing or sealing this space are usually supported from the floating roof which in rising and falling causes the seal to slide over and against the inner periphery of the shell or wall of the tank. Such tanks usually are of relatively large size and, accordingly, the inner periphery against which the seal slides rarely has a true circular form and usually has many other and substantial irregularities.

It is another object of the present invention in the light of the foregoing, to provide an improved deformable weather seal which will maintain a dependably tight engagement with the wall of the tank at all times in spite of irregularities in the surface contour or changes in the curvature thereof.

In addition to the foregoing difficulties, floating roof carried weather seals some times have pockets in which water collects and freezes in the winter. Accordingly, it is still another object of the present invention to provide a new floating roof seal which is constructed to flex and bend as it moves up and down with the floating roof, and in contact with the tank wall, and thus overcome the problem of freeze-ups by preventing ice from forming, and which is additionally free of any pockets or crevices between the wall and the seal where an appreciable amount of water might collect.

Still another object of the invention is to provide a new floating roof weather seal which is entirely free of any metal parts which might come into contact with the surface of the tank wall to produce abrasions therein, but which embodies a continuous flexible air filled cushion around the roof which presses firmly against the surface of the wall of the tank to maintain a fluid and gas sealing contact therewith and to change its form continuously to conform to changes in the surface contour of the wall as the roof rises and falls with the liquid level.

A still further object of the invention is to provide a new floating roof weather seal adapted to be secured to the periphery of the roof and encircle and extend radially outwardly therefrom for sliding contact with the inner surface of the tank shell or wall and which can at the same time conduct to the metal tank wall static or other electrical charges that may accumulate on the roof or be received thereby, in a manner to prevent sparking thereof that would be likely to cause a fire. That is, a roof

seal that will pass to the tank in a non-sparking manner electrical charges received by the roof.

The foregoing and other objects are realized by the provision of a sectional annular band in which the width is radial and which is designed to be secured adjacent to its inner circumference to and around the top edge of the floating roof so that the width of the band extends outwardly therefrom and the outer circumference thereof contacts and is compressed against the inner wall surface of the tank. The band in its sections is of substantial thickness and is made up of a substantially flat envelope or jacket between top and bottom walls or portions of which is secured a yieldable spacer body in the form of sponge rubber and between which spacer body and the outer tank wall engaging portion of the jacket is an air filled chamber.

The outer, cushion forming portion of the sealing band is normally compressed to form a relatively wide wiping or sealing surface which engages the face of the tank wall so that a wide surface sealing contact is obtained rather than a line contact. The casing or envelope has or can have electricity-conducting constituents incorporated therein. The sponge rubber spacer body therein between the top and bottom walls gives the sealing band a substantial degree of rigidity whereby it maintains its horizontal radial extension from the edge of the roof to which it is attached, but at the same time the band is capable of being radially compressed and/or flexed readily either in a downward direction or in an upward direction in the event that the top portion of the roof and the wall of the tank in some area come into close proximity one with the other, and then return to its horizontal sealing position when the spacing between the roof and the wall again widens.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents, are therefore intended to be embraced by those claims.

The invention is illustrated in the accompanying drawings wherein one embodiment of the invention has been chosen for illustrative, but not for limiting, purposes.

In the drawings:

Fig. 1 is a horizontal section taken across a tank structure, a portion only of which structure is illustrated, looking down upon the top of a floating roof therein and showing the weather seal attached to the periphery of the roof and extending outwardly for contact with the inner surface of the tank wall.

Fig. 2 is a plan view on an enlarged scale of one of the sections of the annular seal as it appears before being joined to other sections and fitted to the circular edge of the floating roof, a portion of the section at one end being broken away to show the open end in which an end of another section is inserted.

Fig. 3 is a view in plan of the joined ends of two of the seal sections, the same being shown on an enlarged scale.

Fig. 4 is a sectional view taken substantially on the line 4—4 of Fig. 3.

Fig. 5 is a transverse sectional view, on an enlarged scale, through the seal and adjacent supporting edge portion of the roof.

Fig. 6 is a view, on an enlarged scale and in transverse section, of the assembly layout of one section only of the annular sealing showing the manner in which the parts are initially arranged in the construction of the seal section.

Fig. 7 is a sectional view on an enlarged scale taken

substantially on the line 7—7 of Fig. 1 and showing a normal or light compression of the seal against the tank wall.

Fig. 8 is a sectional view corresponding to Fig. 7 and showing a greater degree of compression of the seal against the tank wall than is shown in Fig. 7.

Fig. 9 is a sectional view corresponding to Fig. 7 but illustrating respectively in full lines and in dotted lines the manner in which the seal is adapted to flex in the upward movement and in the downward movement of the floating roof when the space between the roof and the tank wall has been reduced to a minimum.

Fig. 10 illustrates another means of securing the roof sealing band, or sealing band section, to the roof.

Referring now more particularly to the drawings, the numeral **10** generally designates a storage tank having a cylindrical vertical wall or shell **12** and, if desired, a wind-girder **14** around the upper part of the tank wall. While not illustrated, the tank is provided with a bottom, the general construction of the tank being substantially the same as the tank illustrated in United States Patent 2,735,573, patented February 21, 1956.

The numeral **16** generally designates a floating roof or cover which is positioned within the tank and which, like the floating roof structure of the patent above referred to, includes a circular or peripheral wall **18** and an upper deck **20** which may lie below the top of the wall **18** as shown or flush with the same. Like the floating roof illustrated in the above identified patent, this roof may be provided with a lower deck, not here illustrated, so that there is formed a sealed hollow and circular structure which will float upon the liquid in the tank.

The wall **18** of the floating roof carries at its top edge an encircling flange **21**, here shown as extending radially outwardly, although it may be extended inwardly if desired, and the periphery of this flange is spaced a substantial distance from the tank wall **12** as is clearly illustrated in Figs. 7, 8 and 9, so that between the floating roof **16** and the inner surface of periphery of the tank wall, there is an annular space **22**.

The weather seal of the present invention is secured to the roof carried flange **21** and is generally designated **23**. This weather seal is in the form of a sectional annular band, the width of which is radial as is clearly shown in Figs. 5 and 7 to 9.

The annular band **23** forming the seal is made up of a number of end connected sections each of which is generally designated **24**. Each of the sections **24** of the annular band comprises an elongate substantially flat envelope **25** which is formed of a single length or strip of a synthetic rubber or oil resistant material folded lengthwise upon itself in the manner hereinafter described. Within the envelope is an elongate spacer block **26** of foam or sponge rubber which maintains in vertaically separated relation and substantially parallel under normal conditions, the top and bottom walls **27** and **28** respectively of the envelope.

The envelope **25** of the synthetic rubber is or can be rendered electricity-conducting by being made up of—

	Percent
NA–22 accelerator	0.12
Light calcined magnesia	1.67
Zinc oxide	1.76
Vulcan XC72	35.03
Circo light processing oil	13.59
Stearic acid	0.25
Neophax A	10.98
Type W neoprene	36.60
	100.00

wherein the NA–22 accelerator is (2-mercapto imidazoline) produced by Du Pont; the Circo light processing oil is produced by Sun Oil Co., and is an odorless, light-colored, petroleum oil with a specific gravity of 0.92 and a Saybolt viscosity at 100° of about 155 seconds; the Neophax A is a vulcanized vegetable oil produced by Stamford Rubber Supply Company, with a composition of ash 0.5%, acetone extract 32 to 34%, acetone sol. sulfur 2.8%, with a specific gravity of 1.04; the Type W neoprene is an elastomer prepared by polymerizing chloroprene and is manufactured by Du Point; and the Vulcan XC–72 is a small particle size oil-furnace black manufactured by the Cabot Company.

In the foregoing mixture, the calcined magnesia and the zinc oxide are curing agents. The oil, the stearic acid and the Neophax A are softening agents. The neoprene is the basic rubber compound, while the NA–22 acts as the accelerator. The Vulcan XC–72, which is carbon black in a fine state of subdivision, is the electrical conducting constituent. It is to be noticed that the neoprene is in quantity about one-third the total mixture, and the electrical conducting constituent is used in about the same quantity while the softening agents are used in about 25%. The mixture is vulcanized into sheets from which the envelopes **25** are made. The electrical conducting constituent diminuted particles are such as to leak the electrical charges from the floating roof to the walls of the tank, even though they are embedded in the weather seal in highly dispersed form.

The width of the foam rubber spacer block **26** is materially less than the maximum radial width of the envelope in which it is enclosed and it is so disposed between the outermost part of the envelope and the inner marginal edges thereof as to provide the chamber **29** which in the completed sealing band is completely closed, sealed and filled with atmospheric air.

The upper and lower walls **27** and **28** of the envelope are connected by the rounded outer peripheral or marginal portion **30** and the outermost part of the spacer block or the outer peripheral surface **31** thereof is spaced radially inwardly from this rounded outer portion of the envelope wall to provide the chamber **29** above referred to.

The inner peripheral surface **32** of the sponge or foam rubber spacer block **26** is inset a substantial distance from the inner edges **33** of the envelope walls so that there is a substantial radial width of material between these edges **33** and the inner periphery **32** of the spacer block forming the portions **34** of the envelope walls which are drawn together when the sealing band section is secured to the roof flange **21** by which it is supported.

The inner surface of each portion **34** is reinforced by a strip **35** of heavy fabric, one longitudinal edge **36** of the fabric strip being parallel with and terminating at the adjacent edge **33** of the wall to which it is attached while the opposite or inner peripheral edge **37** of the reinforcing fabric strip extends inwardly to a position where it is caught or sealed between the spacer block **26** and the envelope wall as is clearly shown in Figs. 4 and 5.

In the mounting of the seal band on the flange **21** of the roof the portions **34** of the envelope and the reinforcing bands **35** are pressed together so that these portions curve convergently across the inner peripheral side of the foam rubber spacer block forming shoulders as indicated at **38** and **38***a* and a small hollow space or air chamber is formed at **39** along the inner periphery of the spacer block. The shoulder **38** is at the top of the envelope while the shoulder **38***a* is upon the underside and has a greater degree of curvature.

The foam or sponge rubber spacer block **26** and the fabric strips are of a total length slightly less than the total length of the strip of rubber of which the envelope **25** is formed and they are encased in the envelope with one end flush with the end of the envelope as indicated at **39**[a] in Fig. 2 so that the other ends will be set in from the adjacent end of the envelope leaving an unfilled portion which forms a socket **40** for facilitating the as-

sembling of the sections to form the completed annular sealing band, in the manner hereinafter set forth.

Fig. 6 illustrates an assembly layout of one of the sections 24 of the seal. The strip of the oil-resistant electricity-conducting rubber which is to be used for forming the section 24 of the envelope 25, taken in a desired length and width is laid flat as shown in this figure. The width of the rubber strip is sufficient, when it is folded on a center line, to form the envelope 25 in the desired radial width. With the unreinforced electricity-conducting envelope sheet lying flat, the upper surface has cemented thereto along each longitudinal edge, the heavy fabric reinforcement strip or band 35 as illustrated and there is then cemented to the upturned surface of the rubber sheet or strip the required length of foam rubber spacer block 26. This is disposed at one side of the longitudinal center of the rubber sheet with a portion at the inner peripheral surface 32 overlapping a narrow portion of the reinforcement strip 35 to which it is sealed, as is shown in the figure referred to.

After placing the parts in the manner described, the entire strip of rubber is folded over and cemented to the spacer block with the reinforcing fabric strips 35 cemented together thus producing the four thicknesses of material along major portions of the length of the inner part of the envelope.

The sealing band sections are made in standard lengths and the cushions 34 and the reinforcement strips 35 sealed therebetween are provided with the transverse bolt apertures 41 for facilitating securing the band sections to the flange 21 of the roof.

The seal sections 24 formed in the manner described with the reinforcing fabric strips 35 secured to the rubber sheets contain sufficient lateral rigidity so that it is possible to form them in straight sections in the manner illustrated in Fig. 2 and when made in substantial length the sections may be applied to the curved edge of the floating roof without wrinkling or the developing of irregular sags.

As an example of the weight of the materials used and the lengths of the sections, and without intending to limit the invention in any manner, it may be stated that the strips of rubber forming the envelope 25 may have an initial width of eighteen inches and be approximately one-eighth inch thick and approximately ten feet long. The foam rubber spacer block 26 may have a thickness of approximately one inch and a width of approximately four inches and the reinforcing fabric may be and preferably is common cotton duck material having a weight of approximately fourteen ounces per square yard. With materials of this character and weight the desired lateral rigidity is obtained as above stated so that the sections can be bent to fit the contour of the tank and the roof, without wrinkling.

To form the annular sealing band by the use of the long sections 24, the end 39^a of each section is inserted into the socket 40 of an adjacent section thus making sleeve inserted end joints resulting in a continuous surface along the rounded peripheral portions 30 of the sections for contact with the tank wall.

Fig. 3 illustrates on an enlarged scale the manner in which the end of one section such as the end 39^a, is inserted into the socket portion 40 of another section. In the formation of the sections the sealing together of the opposing faces of the reinforcing strips 35 may be terminated inwardly of the socket forming end as indicated at 42 so that the joined or secured together laminations at the end 39^a of an adjoining section can be inserted. It will be seen then upon reference to Fig. 4 that unreinforced opposing faces of the portions 34 of the envelope in the socketed end of the one section will be positioned against and sealed to the outer surfaces of the portions 34 of the inserted end of the other section.

The apertured inner portions of the band sections are secured to the top surface of the roof flange 21, being placed thereon as illustrated in Figs. 5 and 7 to 9 and the securing together of the parts may be effected in any one of different ways as, for example, there may be employed electricity-conducting metal bolts 43 extended upwardly through apertures 44 in the flange 21, through the apertures 41 and through an annular electricity-conducting metal bolting bar or ring 41*a* and receiving upon their upper ends metal nuts 45 which are tightened down on the bar or ring. When bolts are employed, it is preferred that the heads thereof be secured as by welding to the underside of the flange 21 so that the nuts 45 may be tightened without difficulty and at the same time be assuredly conducting of any electrical charge on the metal roof.

Another method of electricity-conducting securing the sections of the sealing band to the flange 21 would be by the employment of stud bolts as illustrated in Fig. 10 where a portion of the flange of the roof is illustrated and designated 21' and a stud bolt 46 is shown welded to the top of this flange so as to be extended through the opening 41 in a section of the sealing band and then through the bolting bar or ring here designated 41*b*.

In the use or operation of the invention the radial width of the sealing band is such that when the floating roof 16 is concentric with the wall of the tank so that the intervening space 22 is of the same width all around, the outer periphery of the band will be pressed firmly against inner wall surface with a sufficient degree of pressure to flatten the outer part of the air cushion. Thus there will be a relatively wide flat face of the sealing rubber envelope pressed against the wall surface as indicated at 47 in Fig. 7.

In the up and down movements of the floating roof, produced by the liquid content of the tank increasing or decreasing, irregularities in the curvature of the tank wall will cause various degrees of compression of the seal either all around the roof or in discontinuous parts or areas which will cause the seal to flex and compress simultaneously. The seal obtains its deformable characteristics from the foam rubber built therein. The combination of the rubber envelope and the deformable foam rubber spacer therein provides the natural flexible air space. As is shown in Figs. 8 and 9 the seal can be formed completely against the supporting structure without an increase of internal pressure or loss of flexibility.

In Fig. 8 it will be seen that the decrease in the width of the space 22 compresses the seal against the tank wall to an extent where the foam rubber spacer is brought to bear on the outer peripheral face 31 against the inner side of the wall of the chamber 29 and expansion of the envelope takes place both upwardly and downwardly dividing the air chamber into the two sections 29*a*.

Further decrease in the width of the space 22 during the up or down movement of the floating roof will cause the seal to flex and roll against the wall of the tank so that its length will be extended along the surface of the tank wall bringing the top side 27 of the envelope against the wall surface when the seal is bent downwardly and bringing the under wall 28 against the surface of the tank when the seal is bent upwardly as is shown in dotted lines in Fig. 9.

The construction of the seal in that portion in which the small air chamber or air space 39 lies is such as to permit complete flexing of the envelope walls and the reinforcing fabric and a slight compressing of the foam rubber body to permit the seal to bend downwardly or upwardly to the fullest extent as shown in Fig. 9 while at the same time providing the required stiffness and resilience to return the seal to the horizontal radially extended position shown in Fig. 7 when the width of the space 22 is restored to normal. In the present seal construction the flexibility is an inherent characteristic which is required for large irregularities in the tank shell. Also, the flexible or yieldable air space 29 eliminates the severe

wearing problem which is encountered in seals of the type where the sealing action is dependent upon the employment of compression or force imposing means such as springs or levers.

It can thus be seen that this invention besides being directed to novel structural features, also finds embodiment in a flexible seal between the metallic floating roof and the metal wall of the tank covered by the roof, that provides sliding adjustable electricity-grounding contact therebetween that is resistant to hydrocarbons and weather elements while having non-sparking and non-corrosive properties. The electrical conductive rubber seal can be used in the free state, that is not bonded to an insulator yet is abrasive resistant and resistant to hydrocarbons and their vapors yet provides sliding sealing contact between the roof and the tank wall.

I claim:

1. A peripheral sealing rim structure for the floating roof of a round tank having an annular substantially flat and radially horizontally extending sealing band of elastically deformable material engageable upon the surrounding tank wall to have peripheral sealing contact therewith and deflectable upwardly and downwardly, comprising a casing of elastic sheet material formed as a fold with the inward free edge portions thereof bonded together to constitute a relatively stiff horizontal flange portion attachable peripherally to the roof structure, and a spacer-and-filler means comprising an elastically deformable and elastically compressible porous pre-formed body extending longitudinally within the fold and bonded to the horizontal top and bottom wall portions thereof for resiliently interconnecting said walls whereby there is effected a cross-sectional profile of the band providing a radially extending and radially elongated outer body portion and a radially extending inner reduced portion representing the flange portion, the radially outer end portions of said top and bottom wall portions being connected by a peripheral portion, the radially outermost portion of said body being spaced from said peripheral portion to provide an air chamber therebetween whereby the outer peripheral zone of the body portion has a high degree of deforability and inwardly adjacent thereto the body portion has an intermediate zone of less deformability for assuring the combined effects of peripheral sealing contact with the surrounding tank wall as well as assuring resilient self-restoration of said body portion from a deflected to the normal radially-extending horizontal condition thereof, whereby said roof structure is self-restorable from an eccentrically displaced to a substantially concentric normal condition thereof relative to the surrounding wall.

2. Apparatus according to claim 1, wherein the flange portion is spaced from the filler means sufficiently to provide an air chamber at the transition between the flange portion and the top and bottom walls.

3. Apparatus as defined in claim 1, wherein said top and bottom wall portions are made of synthetic rubber including electricity-conducting constituents for conducting electricity from the roof structure to the surrounding wall.

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