Oct. 3, 1961 A. F. FINO ET AL 3,002,828

GASHOLDER SEAL

Filed June 9, 1958 2 Sheets-Sheet 1

FIG.1

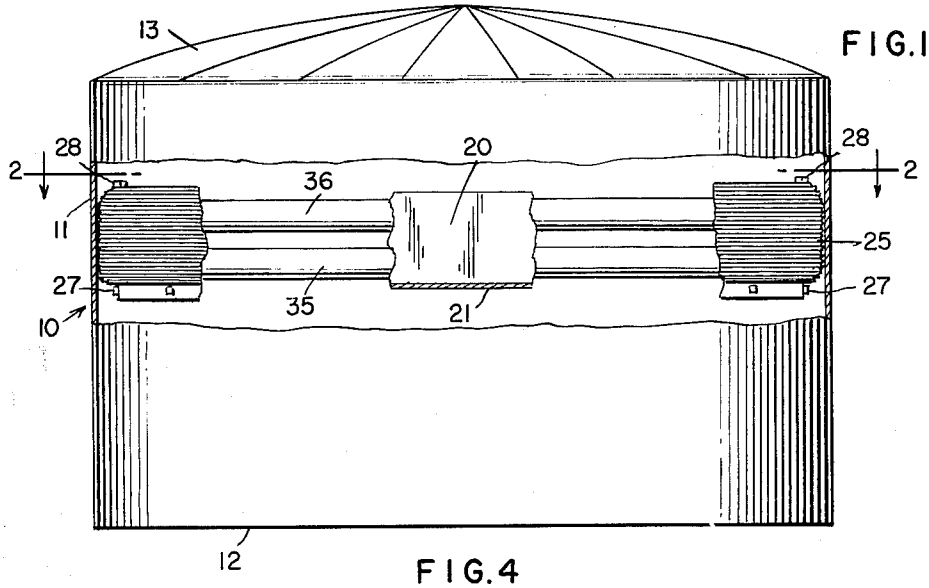


FIG.4

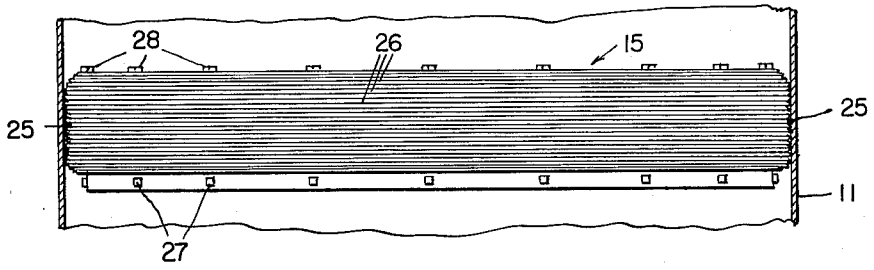
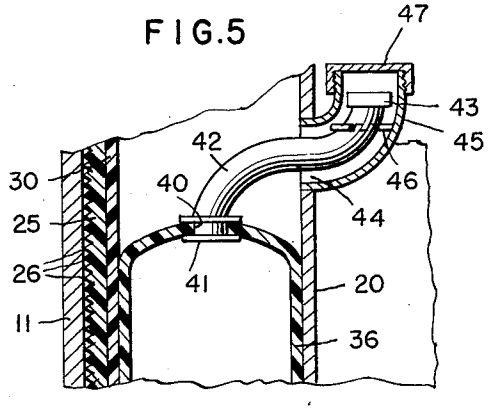


FIG.5



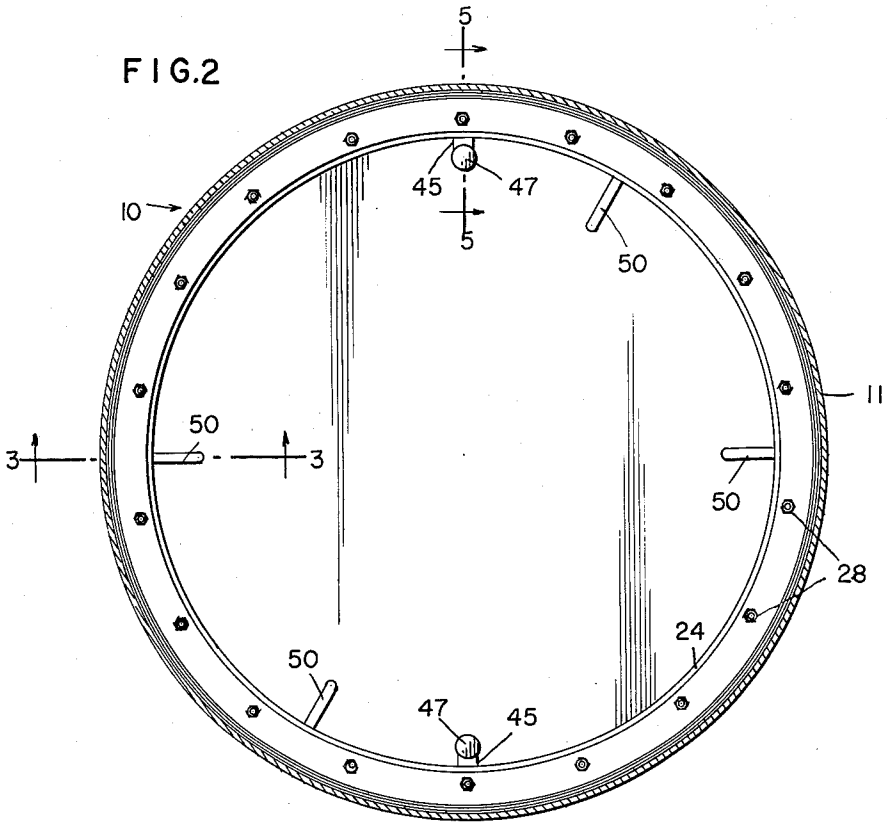
INVENTORS
Alexander F. Fino
BY John M. Swick
Arthur Middleton
ATTY

Oct. 3, 1961 A. F. FINO ET AL 3,002,828

GASHOLDER SEAL

Filed June 9, 1958 2 Sheets-Sheet 2

FIG.2



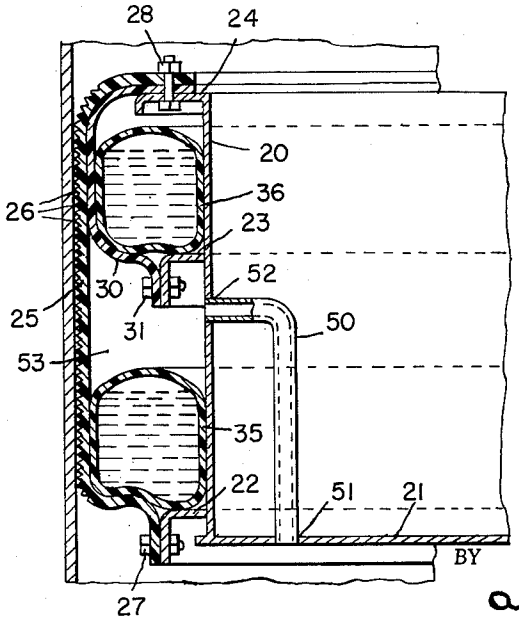


FIG.3

INVENTORS
Alexander F. Fino
John M. Swick
BY
Arthur Middleton
ATTY

United States Patent Office 3,002,828 Patented Oct. 3, 1961

3,002,828
GASHOLDER SEAL

Alexander F. Fino and John M. Swick, Warren, Pa., assignors, by mesne assignments, to Pittsburgh-Des Moines Steel Company, Pittsburgh, Pa., a corporation of Pennsylvania

Filed June 9, 1958, Ser. No. 740,748
7 Claims. (Cl. 48—174)

The present invention relates to storage tanks for fluids, and more particularly to storage tanks of the type wherein it is desired to store city gas, chemical gas and the like, and employing roofs or covers that are supported by the gas within the tank and are adapted to rise and fall in accordance with variations in the gas pressure in the tank.

The covers employed in such tanks are ordinarily of smaller diameter than the inside wall of the tank, and accordingly it is necessary to provide a sealing means for sealing the annular space between the cover and the tank. Numerous sealing devices have been designed in the prior art, and such seals have proved to be satisfactory where employed in tanks of the type wherein liquids such as oil and oil products are stored. However, in applications where it is desired to store fluids in a gaseous form such as chemical gas and the like, the problem of sealing the gas presents certain inherent difficulties which have not been successfully solved with prior art structures.

There are many common problems with storage tanks for gases, and the invention structure is adapted to overcome such conventional problems as well as the specific problems encountered when storing fluids in a gaseous form. Tanks of the type employed for storing such materials are relatively large, and the inner periphery thereof is usually not of true circular form and has other irregularities due to projecting rivets and the like. It is, therefore, necessary to provide a seal which is sufficiently deformable to tightly engage the inner walls of the tank regardless of the irregularities thereof. Prior art seals also often contain water retaining pockets whereby the water therein is caused to freeze in cold weather. The invention structure is designed to prevent the formation of such water retaining pockets.

It has been a long standing problem in the art to prevent excessive abrading and wear on the tank shell as the sealing means moves along the seal in frictional engagement therewith. The present invention structure employs a non-metallic material which efficiently reduces wear on the tank shell to a minimum, and yet is constructed such that it is substantially stiffer circumferentially than vertically.

Prior art tank structures ordinarily employ a sealing curtain attached to the shell and a floating cover in engagement therewith. Such structures limit the upward movement of the cover which is permissible while still retaining an adequate seal between the roof and the tank, and therefore does not utilize the full capacity of the tank. The present invention permits economical storage of gaseous substances since the cover may move upwardly to the top level of the tank, utilizing full capacity and yet retaining a proper vapor seal between the roof and the tank. Many prior art sealing structures provide merely a line contact between the sealing means and the inner surface of the tank, and it is accordingly desirable to provide a sealing means wherein a substantial surface of the sealing means is positioned in engagement with the tank walls at all times.

The cover employed in such large size tanks is subjected to various forces and operating loads during the upward and downward movement of the structure. These various loads acting upon the structures tend to tilt or

cant the structure into undesirable positions and it has been necessary in certain prior art applications to provide stabilizing or leveling devices in order to maintain the structures in proper operative position. Such stabilizing and leveling devices are excessively complex and bulky in construction.

The novel structure according to the present invention employs a pair of liquid containing flexible hollow annular members which are secured to the outer periphery of the cover. These liquid containing members provide a positive centering action for the cover and also function as leveling devices since they create an internal hydrostatic pressure when the original volume of the hollow members is altered. The pair of spaced hollow members acts upon a flexible scuff band adjacent the lower and upper portions thereof for urging the scuff band outwardly into engagement with the inner walls of the tank. The spaced position of the two annular hollow members also provides a stabilizing couple which tends to maintain the cover in a level position at all times regardless of the loads acting thereon.

When storing gaseous materials, it is usually difficult to prevent seepage of gas between the sealing means of the cover and the tank walls. In order to substantially eliminate such seepage, it is an important novel concept of the present invention to provide a very large vertical area of contact between the inner wall of the tank and the outer surface of the annular scuff band secured to the cover. In order to accomplish this, the pair of spaced hollow annular members acts upon the upper and lower portions of the scuff band, and the scuff band is disposed in spanning relationship between the pair of hollow members thereby defining a closed gas chamber between the hollow members, the scuff band and the outer cylindrical surface of the cover. Means is employed for providing communication between the closed gas chamber and the space beneath the lower wall of the cover. In this manner, gas pressure is transmitted from the interior of the tank to the closed gas chamber surrounding the cover.

The gas pressure provided within the closed annular gas chamber about the cover of the present invention is greater than the pressure of the gas tending to seep past the outer periphery of the scuff band, and accordingly the scuff band will be forced outwardly against the inner surface of the tank with such a force that it will positively prevent the gas stored within the tank from seeping upwardly past the scuff band. In this manner, an extremely efficient seal is provided which substantially eliminates any leakage of gas past the sealing means.

The pair of annular hollow liquid filled members of the present invention is partially supported upon flanges projecting radially outward from the roof, and one of the liquid containing members is partially supported by a first flexible annular band, and the second liquid containing member is partially supported by the scuff band which engages the inner surface of the tank. This structure provides a readily deformable seal which will engage a large surface of the interior wall of the tank and will adapt itself to the configuration of the tank regardless of the fact that there may be many minor irregularities therein. Water retaining pockets are substantially eliminated in the invention structure, thereby preventing freezing in cold weather, and the entire sealing structure is formed of a non-metallic material which reduces wear upon the relatively movable parts to a minimum.

The novel sealing structure of the present invention permits the cover to rise to the maximum position of the tank wall, and yet the scuff band will be maintained in firm engagement with the walls of the tank to provide an efficient seal therebetween.

An object of the present invention is to provide a new

and novel seal which is flexible and will be maintained in dependably tight engagement with the inner wall of the tank regardless of irregularity in the tank.

Another object of the present invention is to provide a gas holder seal which substantially eliminates the possibility of water collecting and freezing therein.

Yet another object of the present invention is to provide a gas holder seal which reduces wear of the various elements to a minimum.

A still further object of the present invention is the provision of a gas holder seal which makes use of the maximum tank storage space when the cover is raised to its extreme upper position.

Yet another object of the present invention is to provide a seal which provides a large substantial area of contact between the inner wall of the tank and the sealing means to prevent escape of gas therebetween.

Another object of the present invention is to provide a seal which eliminates the necessity of providing auxiliary stabilizing or leveling devices for the cover.

Other objects and many attendant advantages of the invention will become more evident when considered in connection with the accompanying specification and drawings wherein:

FIG. 1 is a view of a storage tank partly cut away employing a gasholder seal according to the present invention;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1 looking in the direction of the arrows;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2 looking in the direction of the arrows;

FIG. 4 is a view illustrating the cover mounted within a tank according to the present invention; and

FIG. 5 is a sectional view taken on line 5—5 of FIG.2 looking in the direction of the arrows.

Referring now to the drawings wherein like reference characters designate corresponding parts throughout the several views, there is shown in FIG. 1 a storage tank indicated generally by reference numeral **10** including a substantially cylindrical side wall **11** and having a bottom **12** formed thereon in a conventional manner. The floating structure comprising a cover, deck or piston is indicated generally by reference numeral **15** and as seen most clearly in FIG. 4, is disposed within the tank for movement upwardly and downwardly therein in accordance with the gas pressure stored in the tank beneath the cover. The inner floating structure confines the gas and also provides the actuating pressure means for discharging the gas from the gas holder. As seen in FIG. 1, the tank may, in certain instances, be provided with a roof **13** for protecting the interior of the tank from snow loads or the like.

As seen most clearly in FIG. 3, the structure of the floating cover includes a substantially cylindrical side wall **20** having a bottom all **21** secured thereto and sealing the circular space defined by the cylindrical wall **20**. Cylindrical wall **20** is provided with three spaced annular substantially radially projecting flanges **22**, **23** and **24** disposed adjacent the lower wall **21**, at an intermediate portion, and at the upper edge thereof respectively. Each of these flanges is provided with a downwardly projecting end portion for facilitating connection of the various components thereto and are curved so as to reduce the wear on the supported elements to a minimum.

An annular scuff band **25** is formed of a flexible material such as reinforced synthetic rubber having a nylon or equivalent reinforcing core, the synthetic rubber being butadiene, acrylonitrile or the like. The scuff band **25** may also be constructed of electricity-conducting material in the event that electrically charged gas is stored that requires positive grounding at all points. A plurality of horizontally extending ribs **26** are provided on the outer surface of the scuff band and tend to ride over sharp edges of rivets or other protuberances and irregularities on the inner surface of the tank and thereby maintain a tight seal while at the same time reducing wear on both the band and the tank wall. These ribs also give circumferential stiffness and vertical flexibility to the scuff band and prevent capillary creep between the contact surfaces. Scuff band **25** is preferably an endless annular band thereby eliminating any joints or crevices through which gas might escape. The lower edge portion of the outer scuff band is connected to flange **22** by a plurality of spaced nut and bolt assemblies **27**, and the upper edge portion of the scuff band **25** is secured to flange **24** by means of nut and bolt assemblies **28**.

A flexible annular band **30** is disposed inwardly of the outer scuff band and is preferably formed of a material similar to that of scuff band **25**. The lower edge portion of flexible band **30** is secured to flange **23** by means of nut and bolt assemblies **31**, and the upper edge portion of band **30** is secured to flange **24** by the same nut and bolt assemblies **28** which secure the upper edge portion of scuff band **25** to flange **24**.

A pair of spaced similar flexible annular hollow members **35** and **36** is formed of a substance similar to that of bands **25** and **30**, although they may be considerably thinner. The lower hollow member **35** is partly supported by flange **22** and is partly supported by the lower portion of scuff band **25**. Upper hollow member **36** is partly supported by flange **23** and partly supported by the lower portion of flexible band **30**. Each of hollow members **35** and **36** is filled with a suitable liquid material which may be water when employed in climates where the temperature does not drop below freezing, or may be a hydrocarbon such as kerosene when used in areas where the liquid will be subjected to freezing temperatures. The liquid contained in hollow members **35** and **36** under the influence of gravity exert substantially uniform pressures against the upper and lower areas of the scuff band thereby urging the scuff band outwardly into face contact with the inner surface of the tank shell regardless of any irregularities in the surface of the tank shell.

Suitable means is provided for filling each of hollow members **35** and **36** and is illustrated in FIG. 5 of the drawings. Each of hollow members **35** and **36** is preferably provided with two of these filling connections, and each of these connections is preferably identical, whereby only one is shown for the purpose of illustration. The filling connection is shown as employed in hollow member **35**, member **35** being provided with a suitable opening **40** in the upper surface thereof having a substantially rigid surrounding collar **41** which provides an efficient seal with opening **40**. A flexible hose **42** is connected to collar **41** and is provided at the upper end thereof with a suitable tightly fitted cap **43**. Suitable openings **44** are provided through cylindrical wall **20** of the roof, and an upwardly bent protecting tube **45** projects inwardly from opening **44**. Hose **42** is received within tube **45**, and a hose retaining hook **46** is fixed to the inner surface of tube **45** and surrounds hose **42** for retaining the hose in proper operative position. The upper end of tube **45** is threaded and a correspondingly fitted cap **47** is mounted thereon for providing a tight seal therewith.

It is apparent that the level of the liquid within each of the hollow members **35** and **36** may be quickly and easily adjusted at any desired time by removing caps **43** and **47** and inserting or removing liquid into or from the hollow members. The filling connections are easily accessible since they are disposed inwardly of the cylindrical wall of the roof and may be utilized merely by reaching downwardly through the upper open end of the roof, or by standing on the floor or lower wall **21** of the roof, whereupon the filling operation may be carried out in an expeditious manner.

While the aforementioned hollow members provide an efficient seal between the scuff band and the tank

surface, it is an additional important novel feature of the present invention to provide means whereby the scuff band is also urged into engagement with the tank wall by gas pressure existing within the tank of the apparatus. Referring again to FIGS. 2 and 3 of the drawings, four spaced conduits **50** are provided having one end **51** thereof in communication with the space below the lower wall **21** of the roof, and the opposite end **52** thereof in communication with a closed gas chamber **53** defined between the inner surface of scuff band **25**, the lower surface of flexible band **30** and flange **23**, the upper surface of hollow member **35** and the outer surface of the cylindrical wall **20** of the cover. It is apparent that the gas pressure existing in the tank below the lower wall of the roof will be transmitted through conduits **50** to the closed annular gas chamber **53** provided about the roof. The gas pressure within chamber **53** will urge scuff band **25** tightly into engagement with the inner surface of the tank shell. The gas pressure urging scuff band **25** outwardly is greater than the gas which may tend to seep upwardly between the scuff band and the inner wall of the tank, and accordingly a positive seal is provided for preventing gas from seeping upwardly between the sealing means and the tank.

By confining the liquid within the hollow members **35** and **36** to restrict the volume thereof, the hollow members **35** and **36** provide a positive centering and leveling device due to the internal hydrostatic pressure therewithin when the original shape of members **35** and **36** is altered. It is also apparent that the pair of spaced hollow members provides a couple which efficiently resists tilting and canting movements of the cover.

In operation, the cover will rise and fall in accordance with variations in the gas pressure stored within the tank, and scuff band **25** will be maintained in engagement with a substantial area of the inner surface of the tank due to the action of the liquid within hollow members **35** and **36**, and the gas pressure existing in closed gas chamber **53** extending annularly about the roof. The scuff band will be maintained in efficient sealing engagement with the walls of the tank regardless of any irregularities in the tank walls, and water retaining pockets are eliminated thereby preventing freezing of water which might otherwise be accumulated in such pockets. The sealing means is formed of a non-metallic substance thereby reducing wear on the relatively moving parts thereof to a minimum, and it is apparent that the cover is adapted to extend upwardly a substantial distance above the upper edge of the tank walls and yet maintain an efficient seal therewith, thereby efficiently utilizing the maximum amount of storage space in the tank. The spaced pair of hollow liquid filled members provides a coupling action resisting tilting movement of the roof, and the sealing means efficiently prevents escape of any gas stored within the tank due to leakage between the seal and the tank walls.

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, and since the scope of the invention is defined by the appended claims, 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.

We claim:

1. A gas holder having a cylindrical wall, roof, and a bottom wall, a floating cover disposed within said tank adapted to rise and fall in accordance with gas pressure within the tank, said cover being of smaller diameter than the inside of said cylindrical wall to provide an annular space between the periphery of the cover and the tank, a first liquid containing flexible hollow annular member supported by said cover adjacent the lower portion thereof and extending completely therearound, a second liquid containing flexible hollow annular member supported by said cover adjacent the upper portion thereof and spaced from said first hollow member and extending completely therearound, a first flexible annular band having the upper and lower edges thereof connected to said cover and engaging said second hollow member for at least partially supporting said second hollow member and extending completely around said cover, a second flexible annular band having the upper and lower edges thereof connected to said cover and extending completely therearound and engaging said first hollow member for at least partially supporting said first hollow member, said second annular band being spaced from said cover and spanning the space between said first and second hollow members for defining a closed gas chamber therebetween and contacting the inner surface of said cylindrical wall.

2. Apparatus as defined in claim 1 wherein said cover has a bottom wall, and including means for providing communication between said closed gas chamber and the interior of said tank below the bottom wall of said cover.

3. Apparatus as defined in claim 2 including means for introducing liquid into said first and second hollow members.

4. In a gas storage tank of the type including a vertical side wall, roof, and a bottom, a floating cover including a substantially cylindrical side wall and a bottom wall, a first annular flange projecting radially outwardly from said side wall adjacent to the lower portion of said roof, a second annular flange projecting outwardly from said side wall at an intermediate portion of said cover, a first liquid containing flexible hollow annular member extending completely around the cover and partly supported by said first flange, a second liquid containing flexible hollow annular member extending completely around the cover and partly supported by said second flange, a first flexible band extending completely around said cover having the lower edge portion thereof connected to said second flange and having the upper edge portion thereof connected to said cover above said second hollow member, a second flexible band extending completely around said cover and engaging the side wall of the tank having the lower edge portion thereof connected to said first flange and the upper edge thereof connected to the cover above said second hollow member, said second flexible band engaging and partly supporting said first hollow member and also engaging said first flexible band thereby defining a closed gas chamber between said first and second hollow members and the side wall of said cover.

5. Apparatus as defined in claim 4 including at least one conduit means having one end thereof in communication with said closed gas chamber and the other end thereof in communication with the space below said bottom wall for providing communication between the interior of the tank and said closed gas chamber.

6. Apparatus as defined in claim 5 including means for introducing liquid into said first and second hollow members.

7. A gas storage tank having a cylindrical wall, roof and a bottom, a floating cover for gas within the tank adapted to rise and fall in the tank in accordance with the gas pressure therein, said cover being of smaller diameter than the inside of said tank to provide a space between the periphery of the cover and the tank, said cover including a substantially cylindrical side wall and a bottom wall, said side wall having a first substantially radially outwardly projecting flange adjacent the lower edge thereof, said side wall having a second substantially radially outwardly projecting flange disposed at an intermediate portion thereof, and said side wall having a third substantially radially outwardly projecting flange disposed adjacent the upper edge thereof, a first liquid containing flexible hollow annular member extending completely around said cover partly supported by said first flange, a second liquid containing flexible hollow annular

member extending completely around said cover partly supported by said second flange, a first flexible annular band extending completely around said cover and having the lower edge portion thereof connected to said second flange and the upper edge portion thereof connected to said third flange, said first flexible band engaging said second hollow member for partly supporting said second hollow member, a second flexible band extending completely around said cover and engaging the wall of said tank and having the lower edge portion thereof connected to said first flange, the upper edge portion of said second flexible band being connected to said third flange, the inner surface of said second flexible band engaging the outer surface of said first flexible band and also engaging said first hollow member for partly supporting said first hollow member, said second flexible band being disposed in spanning relationship between said first hollow member and said first flexible band for defining a closed gas chamber between said first and second hollow members and the cylindrical side wall of the cover, and conduit means providing communication between said closed gas chamber and the space below the lower wall of the cover.

References Cited in the file of this patent

UNITED STATES PATENTS

2,072,798	Cranz	Mar. 2, 1937
2,366,911	Laird	Jan. 9, 1945
2,723,908	Wiggins et al.	Nov. 15, 1955
2,735,573	Fino	Feb. 21, 1956

FOREIGN PATENTS

632,995	Germany	July 17, 1936