

May 17, 1938.

T. M. GOODRICH

2,117,314

GAS HOLDER

Filed Sept. 29, 1934

2 Sheets-Sheet 1

Fig. 1.

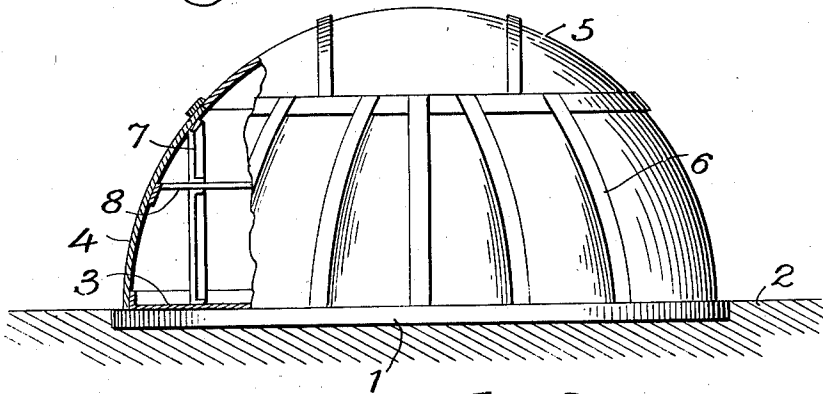


Fig. 2.

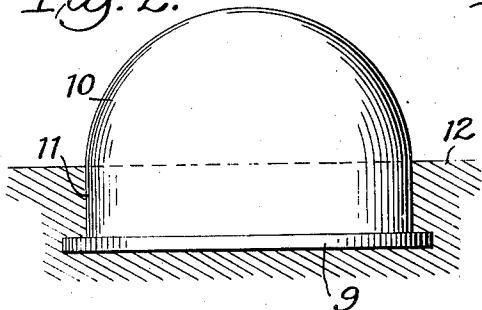


Fig. 3.

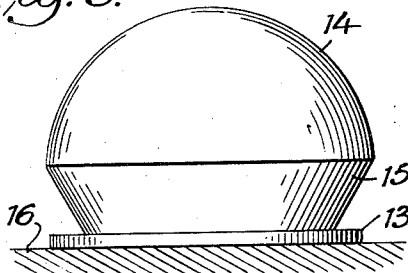


Fig. 4.

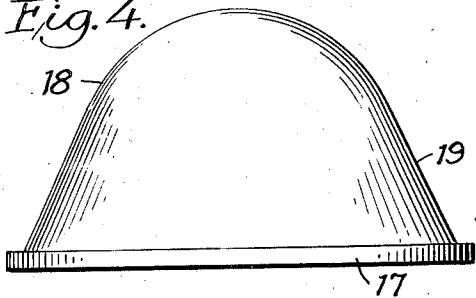


Fig. 6.

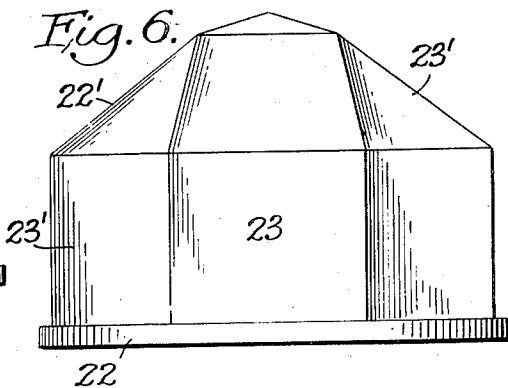
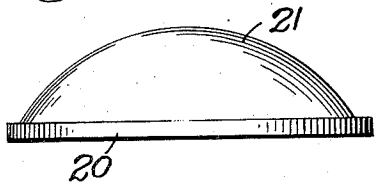


Fig. 5.



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2 Sheets-Sheet 2

Fig. 7.

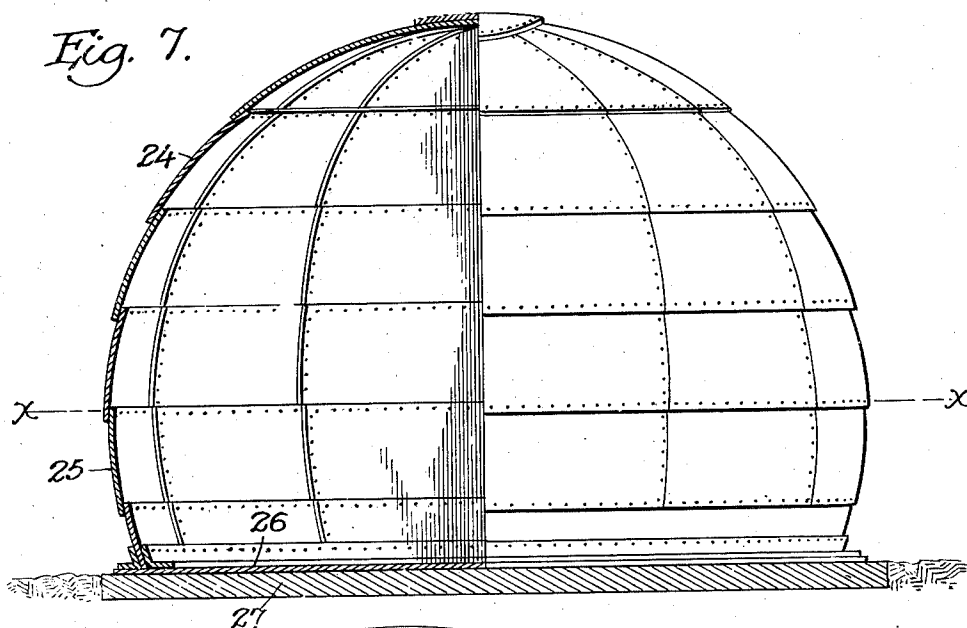
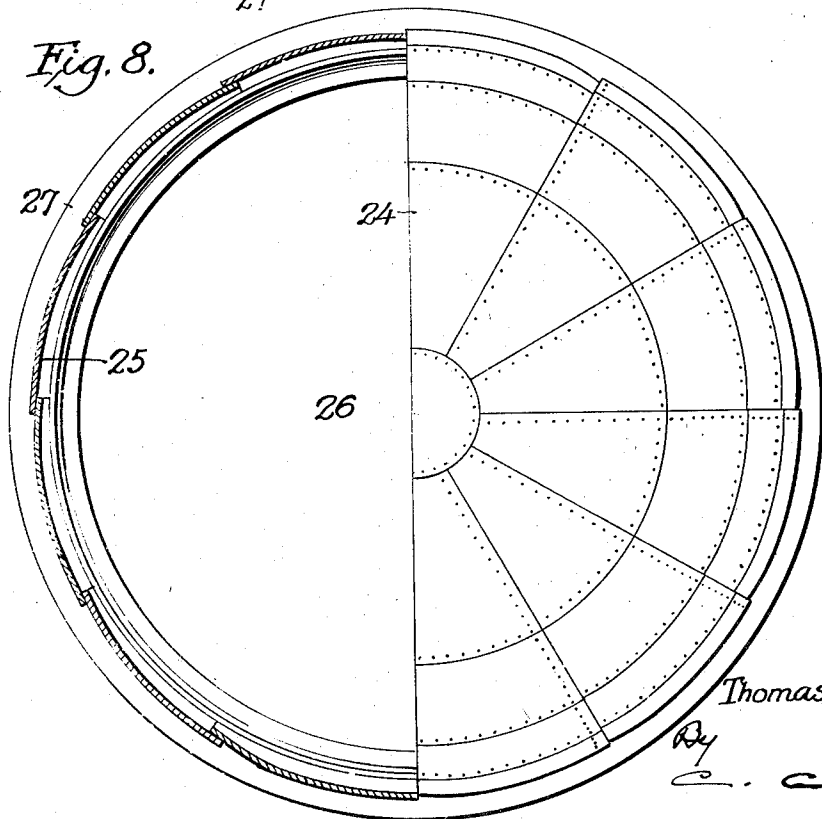


Fig. 8.



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UNITED STATES PATENT OFFICE

2,117,314

GAS HOLDER

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Application September 29, 1934, Serial No. 746,219

2 Claims. (Cl. 220—1)

This application is a continuation-in-part of and successor to my prior application filed November 7, 1931, Serial No. 573,669, allowed April 18, 1934, in which certain features disclosed in the present application will be found.

This invention relates to improvements in gas holders, and has special reference to improvements in that type of gas holder designed for storing a large quantity of gas under pressure and to take the place of and obviate the well known objections to the telescoping water-sealed gas holders, and what are known as waterless holders, namely, the two well known types of gas holders now commonly employed by gas companies for storage of gas for supplying the inhabitants of cities, towns and other communities or large consumers with illuminating, heating or other gases.

In order to overcome some of the objections to the above-noted types of gas holders, and to provide a holder having economic as well as service advantages, it has heretofore been proposed to use a holder in the form of a closed metallic shell of spherical (ball) or a generally similar shape, anchored at its base to an annular row of piers and/or other foundation supports on the ground. Such spherical types of holders have been practically used with success for the storage of volatile liquids, such as gasoline, petroleum and the like, in which the liquid is stored under an internal gas pressure. In such liquid holders the dead weight of the shell and its liquid contents and a portion of the internal gas pressure fall upon the curved bottom of the shell, making it necessary to strongly brace the bottom and the adjacent portions of the side walls of the shell in order to prevent collapse or rupture or distortion of the shell at the juncture of its bottom and side walls due to its tendency to flatten out under such dead weight of the shell and the weight of the liquid and the gas pressure. Because of the amount of weight sustained by the supporting piers it is also necessary to deeply imbed the piers and/or to make them of excessive strength in order to prevent unequal sinking of the piers and rupture of the anchor fastenings between the same and the shell, where the ground site is of poor supporting character, thus making the foundation cost comparatively high. The main problem involved in firmly supporting and anchoring such shells is, therefore, that of preventing distortion or rupture due principally to dead head weights, the problem of displacement or overturning, under pressure of wind storms, for example, being relatively unimportant, because the weight

of the holder and its contents assist very materially in holding the shell in place and maintaining its stability as against overturning in wind storms.

Containers of spherical shape for holding gas under pressure and supported in the same manner as liquid holding shells as above set forth have also been employed, but such containers when used as gas holders have structural, economic and esthetic disadvantages. The use of a container of spherical shape as a holder for gas, for example, presents a different anchorage problem from that involved when such containers are used for the storage of liquids. Gas stored under pressure in a sealed spherical container exerts its pressure equally in all directions on the walls of the spherical shell. Such a shell is not only open to the objection that the bottom of the shell tends to flatten out under the dead weight of the shell itself and the pressure of the gas on the incurved lower portions of its side walls, with the result that such portions of the side walls are liable to spread and rupture, but such a shell stored with gas tends to float and to be displaced or overturned by wind pressure in high wind storms unless the shell is very securely anchored to the ground. This requires the construction of a foundation of very expensive character, especially in the case of poor ground support, and generally also the use of an outer set of anchor legs, in addition to the piers and other foundation supports and anchor connections between the same and the bottom of the shell, not only to prevent distortion of the shell bottom and rupture of adjacent portions of the shell, but also to prevent the added liability of breakage of the anchor connections and the overturning of the shell by wind forces in storms when high winds prevail. Another objection to these spherical shells, which are commonly made of segmental sections riveted together, is that it is necessary, because of the form of the shells, to set up the shell and excessively bolt all sections together to substantially support the shell before the riveting can be performed, thus still further increasing the cost of erection, and as with this construction of shell it is impossible to prevent some degree of distortion of the shell walls owing to deflections due to its dead weight, it is also impossible to preform the rivet holes at the factory so that they will accurately register in the lapping portions of the set-up sections, and consequently the expensive field work of reaming out the rivet holes is required in order to secure their registration before the rivets can be applied. Still another

and very important objection against the use of spherical gas shells is the excessive height of the shell, when of large capacity, which is a cause of complaint, for esthetic reasons, on the part of property owners in the communities where such shells are used or to be erected.

My invention overcomes all these objections to the construction and use of prior gas holders of spherical type, while at the same time retaining all the substantial advantages of a closed container of this type, by making the shell body of suitable dome-like or partly spherical formation and providing the shell with a flat bottom of a diameter substantially equal to or closely approximating the major diameter of the shell, which bottom is disposed along a chord line in such relation to the top and side walls of the shell body as to receive and sustain all or substantially all of the downward pressures of the gas, including those pressures which would, in a shell of true spherical or similar shape, be directed against the intumed bottom portions of the side walls as well as the bottom of the shell. Such dome-like or partly spherical form of shell is mounted, in accordance with my invention, upon a substantially flat, horizontal pressure sustaining and distributing foundation base support. By this means a shell is produced which is substantially of beehive conformation, and in which the weight of the shell and downward pressures of the gas are sustained by the foundation support and a flat horizontal bottom of effective area provided to receive and transmit such weight and pressure uniformly to the foundation support and ground. As a result the portions of the side walls of the shell adjacent to the bottom wall are not only relieved of the downward pressures of the gas and reinforced by the bottom plate and prevented from bulging and rupturing, but the shell will be firmly supported and held from floating and overturning without the necessity of using expensive anchorage connections even in the presence of the strongest winds and the construction of the foundation on poor ground sites. Furthermore, this construction of the shell and its foundation not only avoids the necessity of using external outstanding braces, except in cases of extreme precaution, because of this pressure relieving action, or the use of bracing for the bottom wall, since the latter rests solidly upon the foundation support, but in the vast majority of cases also obviates the necessity of using any bracing means except the fastening connections at the joints of the shell sections themselves and between the shell and base. Additional advantages of my invention are, first, that the top and side walls may if desired be made of metal of uniform thickness, while the bottom may be made of metal of less thickness, thus securing a considerable saving in cost of material; second, that as the flat bottom rests squarely upon the foundation support, the weight and pressure are distributed uniformly over such a very wide area that a less costly construction of foundation proper may be used, even where the ground is of poor supporting character, as adequate support for the holder will be afforded even in case of the settling of the ground; third, the self-supporting form and construction of the holder prevents wall deflections in setting up the shell and permits of the setting up and riveting together of its parts with little or no reaming out of rivet holes and without the necessity of completely bolting them together as a unit before riveting; and fourth, the conformation of the shell is of

more pleasing character than a spherical shell, and as an increase in diameter to secure added capacity does not proportionately or objectionably increase the height of the shell.

One object of my invention, therefore, is to provide a construction of gas holder which embodies all the advantages of a holder of spherical form while being free from its disadvantages, and which enables a simpler, more economical and more reliable and efficient construction of holder and foundation therefor to be built.

A further object of this invention is the production of a simple and efficient gas holder which is easy to erect and wherein the cost of erection is comparatively cheap as compared with the cost involved in erecting other types of gas holders.

Another object of this invention is the production of a simple and efficient gas holder which may be constructed upon a flat foundation, thereby eliminating the tendency which is experienced in other types of spherical gas holders to spread or flatten out.

My improved gas holder has no moving parts and may be used in practically any case where gas is utilized under pressure. The construction of the base will greatly reduce the cost by eliminating the formation of complicated piers and the like, which have been in use in many instances. By providing a dome-like structure in accordance with the present invention, the surface may be quite easily painted and presents a smaller area per unit of space than the well known lift holders, thereby greatly cheapening the cost of painting. The entire device may be painted attractive colors to harmonize with the surrounding scenery if desired.

By eliminating the usual water seals, the device is especially adapted for use in cold climates by preventing the danger of freezing.

A further object of this invention is the production of a simple and efficient gas holder having a minimum amount of weight, and not only the dead weight of the shell but the downward pressure of the gas will be taken up by the flat base and distributed uniformly over a wide area to the foundation and the supporting surface of the earth below this foundation.

Other objects and advantages of the present invention will appear throughout the following specification and claims.

In the drawings:

Fig. 1 is a side elevation partly in section of one form of the gas holder.

Fig. 2 is a diagrammatic view of a second form or design of the gas holder.

Fig. 3 is a diagrammatic view of a third form of the gas holder.

Fig. 4 is a diagrammatic view of a fourth form of the gas holder.

Fig. 5 is a diagrammatic side view of the fifth form or design of the gas holder which may be used in carrying out the present invention.

Fig. 6 is a modified form of the gas holder showing a many sided body design which may be used.

Fig. 7 is a sectional side elevation of still another modified form of the gas holder.

Fig. 8 is a sectional plan view of the holder shown in Fig. 7.

By referring to the drawings, it will be seen that 1 designates the enlarged flat base which may be sunk flush with the surface of the ground 2, as is shown in Fig. 1, and may be placed upon the top surface of the ground if it is desired. Preferably

a metallic floor or bottom 3 is employed upon the base 1 and to this floor or bottom 3 is secured side plates 4 which constitute the body or shell 5 of the gas holder, which, in the form of the invention shown in Fig. 1, is of substantially hemispherical form. This body may be formed of a plurality of plates of the usual type which may be welded or secured together in any suitable or desired manner and sealed over their adjoining edges by means of the butt-straps 6 if desired. Suitable vertical braces 7 and transverse braces 8 may be employed when desired, though ordinarily not necessary.

It will be seen that as the dome-like body or shell 5 is formed as the part of a sphere of proper diameter above the diameter line, or, in other words, is of hemispherical form, the chord line of its normally open horizontal base, which is closed in the completed holder by the bottom wall 3, is coincident with its point of major diameter and lies at a point where the side walls of the body or shell are vertical or substantially so, the wall 3 thus being placed along such a chord line or at such a level with relation to the top and side walls of the shell that all or substantially all the downward pressures of the gas are removed from the shell body and directed against the bottom wall 3. The side walls 5, in other words, are free from curved portions below its horizontal plane of major diameter extending inwardly to such a degree as to lie in the path of downward pressure of the gas. The horizontal wall 3 which is substituted for the lower half or portion of the sphere receives and sustains the downward pressures which in the use of a spherical shell fall upon the base and inwardly curved side walls of the lower half of such a form of shell, and which tend to cause buckling and disruption of the lower portions of the sides of a spherical shell, particularly under conditions where the bottom of the spherical shell is under a stress causing it to flatten out. While this shape, i. e., hemispherical, is shown in the specific form of the invention disclosed in Fig. 1, it is to be understood that this is merely illustrative of one specific form of the invention, as the shape of the partially spherical body and position of the chord line or line of bisection may be, within the spirit and scope of my invention, at any point above the diameter line, or at any point or level between the diameter line and base line of the circumference of the sphere, and sufficiently above the latter to adapt the bottom wall to be placed along a chord line in proper position with relation to the bottom and side walls of the partly spherical or dome-like holder shell to receive and sustain all or a materially greater proportion of the downward pressures of the gas. If, for example, the shell body extends on the arc of the circumference of a sphere to a degree greater than a hemisphere, i. e., more than 180°, so that the side walls of the shell project below the 180° diameter line in the form of depending side wall portions, the extent or limit of downward projection should be limited to a degree such that the depending portions of the side walls are vertical or are inwardly curved or inclined to such a small degree that they will lie substantially outside of the line of downward pressure of the gas. The effect of this result is to enable a flat bottom of a diameter substantially equal to that of the major diameter of the shell to be used and substantially all the weight of the shell and the downward pressures of the gas to be transferred thereto and to the foundation. This principle will apply in the case of making

the depending portions of the walls cylindrical, that is, of equal diameter at any point, or of inclining or curving such wall portions inwardly to a small degree provided that the base of the shell is not unduly contracted with respect to its major diameter and that the diameter of the shell closing portion of the bottom wall will be such as to receive and sustain the major portion of the downward pressure of the gases and at the same time form a stable base support for the shell. By this principle of construction the strength of a dome-topped or spherical body form is obtained with an avoidance of pressures liable to cause disruption of the side walls and with the enormously increased strength and stability afforded by a flat base by which any tendency of the body to float or balloon is overcome and the body adapted to be stably supported against displacement or breaking loose from its foundation and overturning under wind pressures. The great area of support by the bottom 3 thus afforded will, where cheapness of construction is essential, allow the holder to rest directly on the ground under optimum conditions when the ground is sufficiently firm, without the necessity of building the foundation support, and, even in the event that the ground is soft, loose or spongy, the foundation support provided may be inexpensively constructed while made of sufficient strength to carry the weight and stand all stresses and strains imposed upon it. The great area of this foundation also effects such a distribution of the load throughout its superficial area as to relieve it from undue stress at any point liable to cause fracture, and by reason of this fact any uneven settlement of the ground beneath it will not affect its stability beyond a determined safety factor limit. As the bottom wall 3 lies flatly in contact with this foundation it is backed and reinforced thereby to such a degree that a bottom wall made of thinner metal, as shown, or less cross-section than the metal of the body or shell, may be used, with resultant economy. Furthermore, owing to its shape and that of its bottom wall and foundation support, the segments of which the body 5 are formed may be easily set up and riveted together, with a minimum amount of previous bolting and rivet hole reaming, and with a saving of time and expense in this connection not possible in the use of a full spherical body in the construction of which the shell sections must be completely set up and firmly and excessively bolted together, and the bolts of the respective sections individually or in small numbers removed for the final reaming and riveting operations. With my improved construction bracing, if and when required, is considerably less than that required with spherical holders, so that this expense in construction is either eliminated or materially reduced.

In Fig. 2 there is shown a modified form of the dome-like holder wherein a base 9 is employed, upon which the substantially hemispherical body 10 is mounted and secured, which body is provided with a cylindrical base portion formed by side walls 11 depending below the diameter line. This base and part of the body may be sunken below the surface of the ground 12, as shown, if desired. In this construction, as in that shown in Fig. 1, the base of the body, closed by the bottom wall 3, is of a diameter equal to the major diameter of the body, and hence all the downward pressures of the gas fall upon the wall 3 and, with the weight of the shell, are sustained thereby and by the foundation support 9 and

the portion of the ground on which said foundation support rests.

In Fig. 3 is shown a still further modified form of the invention wherein a base 13 is employed upon which the dome-like, substantially hemispherical gas-containing or gas-holding body 14 is mounted, this body being provided with inwardly inclined side walls 15 near the bottom thereof for engaging the base 13. In the structure shown in Fig. 3, the base 13 is shown resting directly upon the surface of the ground 16. In this structure the base of the body formed by the walls 15 is reduced to some extent in diameter with respect to the major diameter of the body proper, and consequently the lower portions of the depending walls 15 lie in the plane of some of the downward pressure of the gas. This diameter reduction may be so chosen or of such a degree that the amount of the downward pressures falling upon the walls will not be sufficient to cause bulging, since the diameter is sufficient to cause the greater proportion of the downward pressures to fall upon the flat bottom wall. This form of the invention may be used under some conditions.

In Fig. 4 there is shown a still further modified form of the invention wherein a base 17 is employed upon which a dome-like gas-holding body 18 is mounted which is of substantially hemispherical form having outwardly inclined side walls 19 near the lower end thereof, which walls are secured at their lower extremities to the base 17. In this construction the shell is as a whole cone-shaped and the diameter of the bottom wall 3 is equal to the major diameter of the body and the same advantageous results are gained.

In Fig. 5 there is shown a still further modified form of the invention wherein a base 20 is employed upon which a shallow dome-like hemispherical body 21 is secured. In this structure the base of the holder is at the horizontal plane of maximum diameter and all the downward pressures are received by the wall 3. This is a very efficient type of construction for holders of small capacity.

By providing the substantially flat base as illustrated, the gas holder may when required be very cheaply constructed and by the use of a dome-like hemispherical body the holder may be set at its base into the ground so that only a comparatively small portion of the gas holder will show above the ground, if desired. Furthermore, any tendency to overturning movement is prevented due to the fact that the holder is solidly supported on a flat base and that a considerably less area is presented or exposed to wind pressure owing to the shape of the body itself. Also by the use of a dome-shaped holder of any of the forms shown a holder of large size and considerable capacity may be used which, even when set in a foundation resting directly upon the ground surface, will be of less height than a spherical holder of like capacity, and thus less objectionable in this respect for use in residential or business sections for esthetic reasons.

It is not desired to limit this particular invention to the particular structure of the base so far as the make-up is concerned, as this base may be formed of concrete or a combination of steel or concrete, or of any suitable or desired formation without departing from the spirit of the invention.

It should be understood that changes in the mechanical construction may be employed with-

out departing from the spirit of the invention so long as these changes fall within the scope of the appended claims.

In Fig. 6 there is shown a further modified form of the design showing a many sided type of body which may be used in connection with the present invention. In this structure a base 22 is employed upon which the multi-sided shell body 23 is mounted, said body having a pyramidal or other form of multi-sided top 22', the body and top being formed by assembling the angularly arranged plates 23'. In this construction the base of the holder closed as in the other holder structures by the bottom wall 3, is of the same diameter as the body 23 and all the downward pressures are therefore received and transferred from said side walls to the wall 3 and supporting foundation. It will be understood that any of the forms of my invention may likewise be formed of angularly arranged plates while preserving the general form of the holder structure.

In Figs. 7 and 8 I have shown still another modified form of my invention in which the dome-like shell is of partly spherical conformation and comprises a hemispherical body 24 having depending side walls 25 extending to a degree below the diameter line $x-x$. It will be observed that in this construction the side walls 25 continue on the line of spherical curvature of the body but terminate at a point or level sufficiently above the base line of a true sphere and between the same and the diameter line where the degree of downward and inward curvature of the side walls is comparatively small and does not materially reduce the diameter of the base of the shell with respect to the diameter line. This point or level may vary within certain limits as any particular diameter of shell or other circumstance or the exigencies of the case may require in practice. In the present instance it is shown as at a point corresponding more or less to that of the 20° point or parallel of latitude south of the equatorial (or diameter) line of a terrestrial globe, at which point or level the bottom wall 26, resting solidly on the flat supporting foundation 27, is placed, but I do not limit the invention to this particular arrangement. The selected point of placement of the bottom wall 26, however, desirably may be the degree point where, owing to the downward and inward curvature of the walls 25, a certain degree of downward pressure of the gas on the side walls occur but not to a degree sufficient, on account of the type of supporting bottom and base used, to cause bulging even in the case of the storage of the gas under very high pressure. At this point the diameter of the shell base is not materially contracted and therefore the bottom wall 26 may be of a diameter substantially equal to the major diameter of the shell and of such large diameter as to receive and sustain the major portion, namely, for practical purposes substantially all of the downward pressures of the gas and to relieve the side walls therefrom. The large area of support here given to sustain the dead weight of the shell and downward pressure of the gas is sufficient not only to sustain the shell against overturning even in the presence of high winds but also to sustain the walls 25 against outward bulging and rupture without the use of complex bracing of the kinds heretofore required, since the walls 25 are additionally relieved of the mechanical pressure incident to flattening of the bottom wall in a holder of true spherical type, which cannot occur with the use of the flat bot-

tom wall 26 and flat foundation 27. In the construction shown the shell body and its depending side walls are made of sections of sheet metal of uniform thickness lapped and riveted at the joints, but, if desired, the metal sections may be welded or otherwise united and butt-
 5 straps of usual type may be provided or not over the joints. This construction also allows the bottom wall to be made of metal of less thickness than the shell walls with resulting economy.
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It will be seen from the foregoing that my invention in its various forms disclosed provides a closed fluid pressure tank consisting of enclosing relatively thin walls, said tank comprising an upper body portion and a substantially flat bottom both having sufficient tensile strength in their walls to inherently withstand the internal gas pressure, said body throughout its major portion being substantially semispherical in shape, said bottom at its annular periphery being sealed and anchored to the body portion substantially in the region of its greatest horizontal periphery, whereby on account of the stresses in the aforesaid horizontal periphery the tank bottom is stretched and maintained in a substantially horizontal condition.
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In all of these forms also a holder body is provided which is of dome-like formation, with its attendant advantages above set forth, and closed by a flat bottom wall which receives and sustains all or substantially all the downward pressures of the gas and which rests squarely upon a flat, horizontal supporting foundation constructed to rest solidly upon the ground, where-
 30 by the bottom wall is solidly backed against distortion or deflection, the holder supported so as to effectually resist overturning under the strongest wind pressures, and the weight of the holder and pressure distributed equally to all portions of the supporting foundation and the ground, so that a stable structure is provided to resist displacement and distortion under all weather and ground conditions.
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A further and important advantage of my invention is that the sections of the shell may be set up and preliminarily bolted in tiers before riveting in the manner similar to the erection of a brick wall. This facilitates and expedites erection, as the rivet holes in the plates may be pre-formed at the factory so as to ac-
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curately match when the plates are brought together for preliminary bolting and without the necessity of reaming out the holes to match on the removal of the bolts and placing of the rivets. Also, as with this construction of shell, no material outward bulging of the shell walls occurs under dead weight, as in a spherical shell, in the event that the shell is completely set up and bolted prior to riveting, this mode of construction may be resorted to without the necessity of reaming out the bolt holes for the rivets when the bolts are removed, and the rivet holes may therefore be made in the plates in final form for use entirely in the factory at the time the plates are produced.
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What I claim is:—

1. A closed fluid pressure tank consisting of relatively thin enclosing walls, said tank comprising an upper body portion and a substantially flat bottom both having sufficient tensile strength in their walls to inherently withstand the internal gas pressure, said body throughout its major portion being substantially semispherical in shape, said bottom at its annular periphery being sealed and anchored to the body portion substantially in the region of its greatest horizontal periphery, whereby on account of the stresses in the aforesaid horizontal periphery the tank bottom is stretched and maintained in a substantially horizontal condition.
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2. A closed fluid pressure tank consisting of enclosing relatively thin walls, said tank comprising an upper body portion and a substantially flat bottom both having sufficient tensile strength in their walls to inherently withstand the internal gas pressure, said body throughout its major portion being substantially semispherical in shape, said bottom at its annular periphery being sealed and anchored to the body portion substantially in the region of its greatest horizontal periphery, whereby on account of the stresses in the aforesaid horizontal periphery the tank bottom is stretched and maintained in a substantially horizontal condition, and a rigid horizontal foundation base disposed beneath said bottom throughout its area and sustaining the same against the weight of the tank and downward pressure of the gas falling thereon.
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