Oct. 15, 1963 G. B. HOLCOMBE 3,106,772

METHOD OF ERECTING BUILDINGS, TANKS, DOMES OR SIMILAR STRUCTURES

Filed Aug. 20, 1959 3 Sheets-Sheet 1

FIG_1

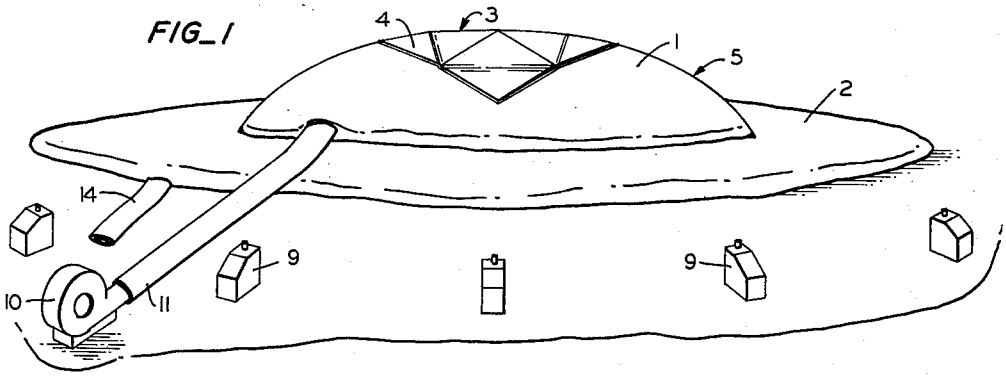


FIG_2

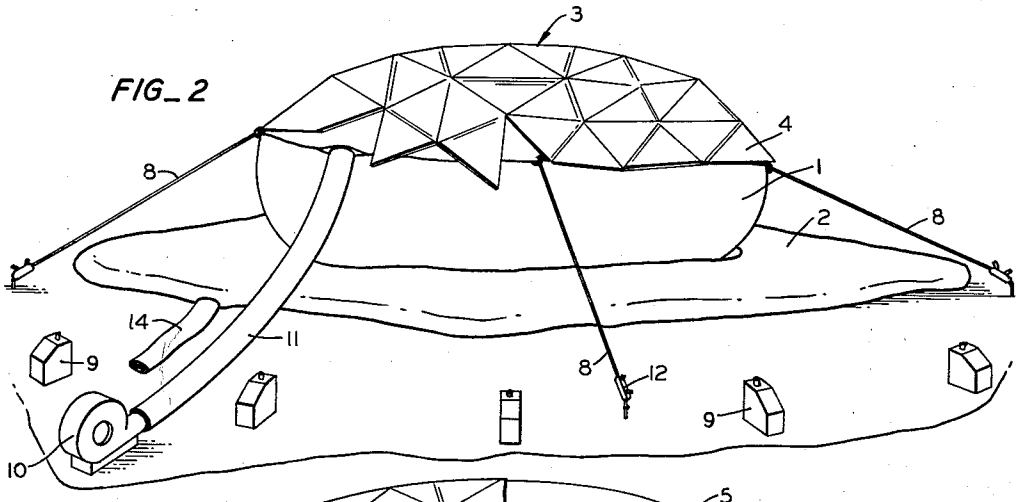
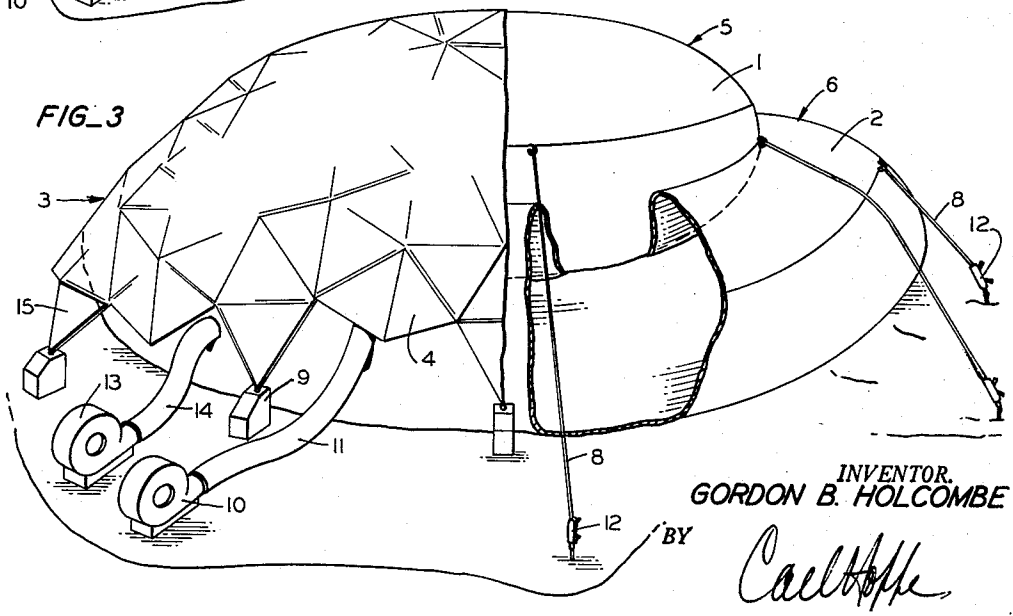


FIG_3



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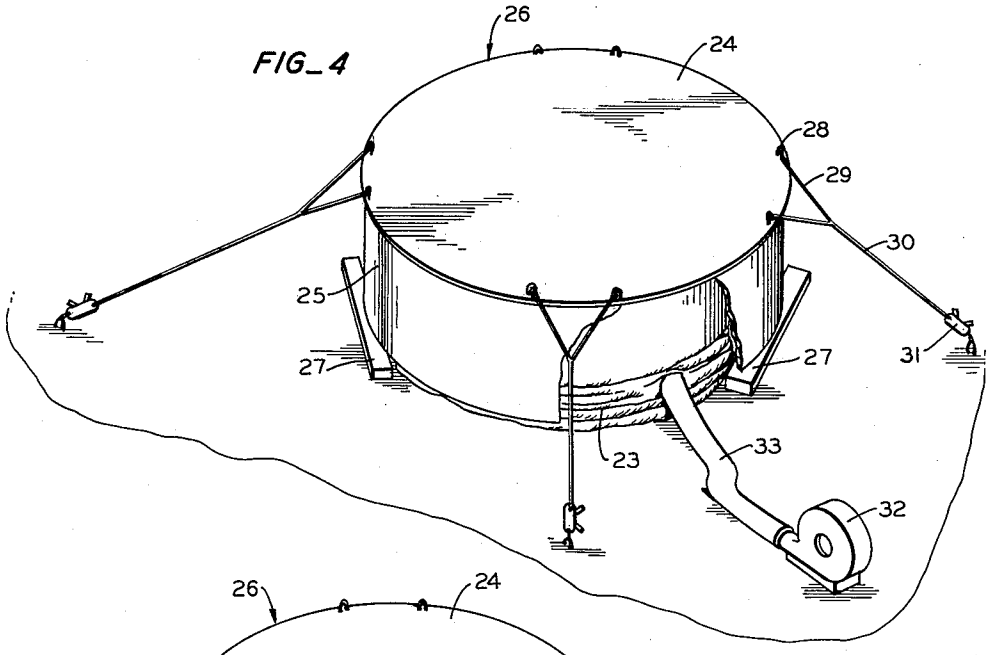
ATTORNEY

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METHOD OF ERECTING BUILDINGS, TANKS, DOMES OR SIMILAR STRUCTURES

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FIG_4



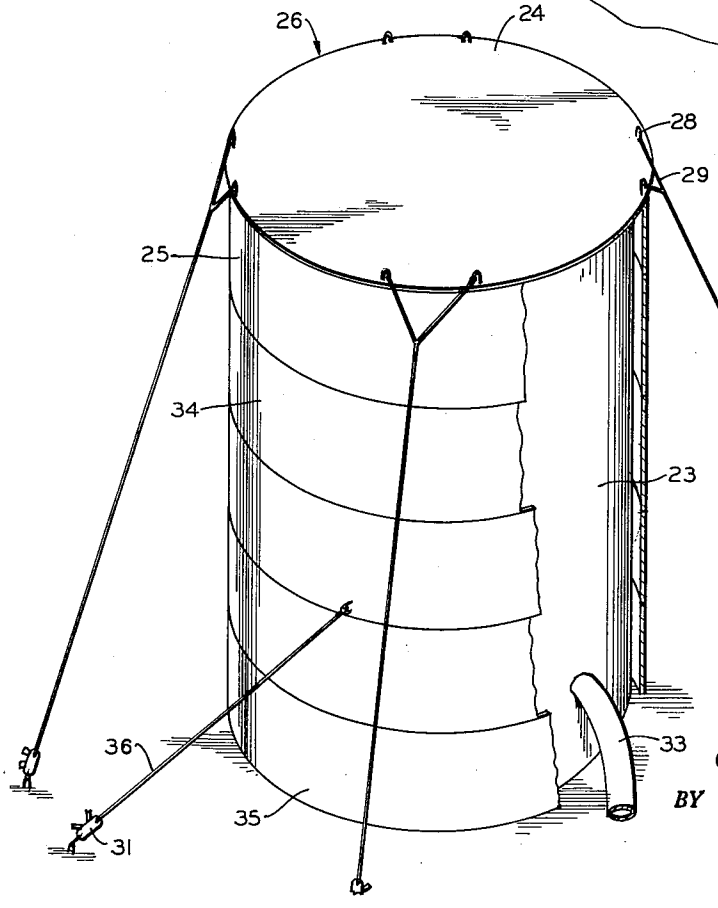


FIG_5

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METHOD OF ERECTING BUILDINGS, TANKS, DOMES OR SIMILAR STRUCTURES

Filed Aug. 20, 1959 3 Sheets-Sheet 3

FIG_6

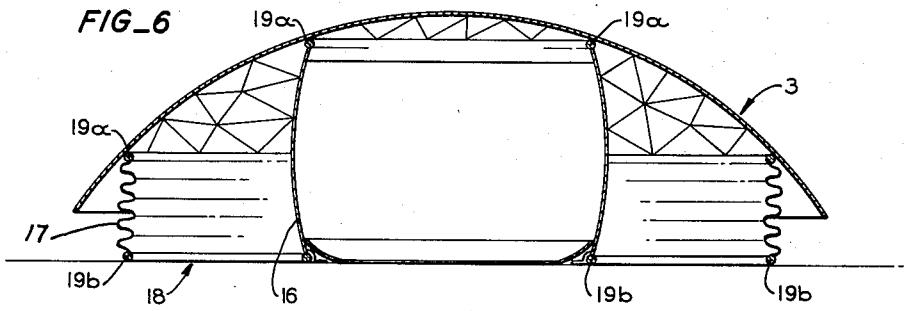
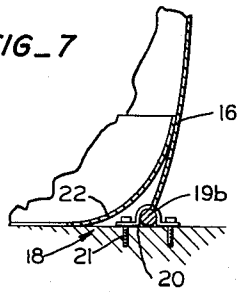


FIG_7



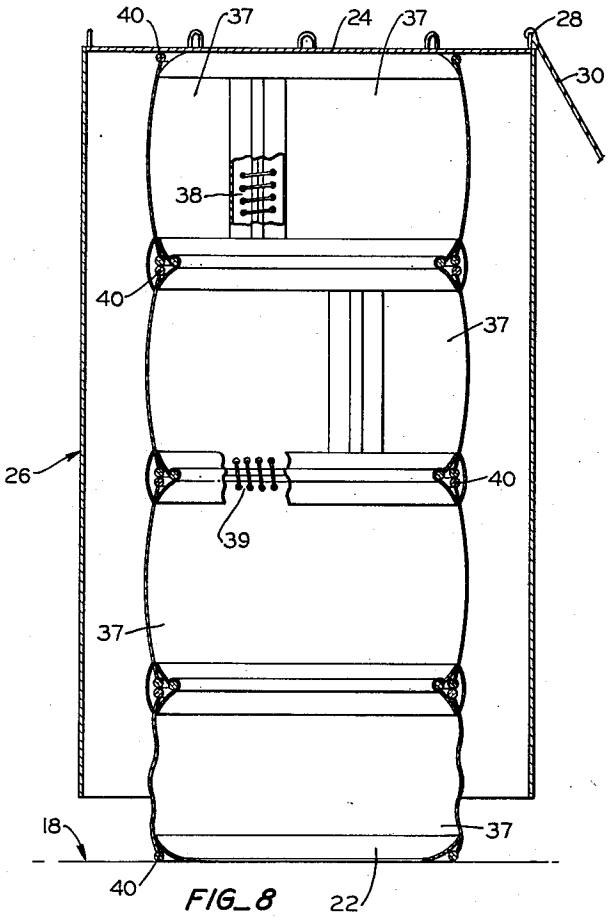


FIG_8

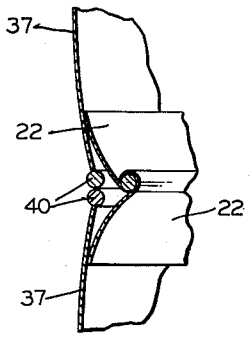


FIG_9

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United States Patent Office

3,106,772
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3,106,772

METHOD OF ERECTING BUILDINGS, TANKS, DOMES OR SIMILAR STRUCTURES

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Filed Aug. 20, 1959, Ser. No. 835,139
1 Claim. (Cl. 29—429)

This invention relates to a new and improved method of erecting buildings, tanks, domes or similar structures and comprises a continuation in part of my application Serial No. 778,035 presently bearing a filing date of November 14, 1958, now abandoned, for method and apparatus for erecting buildings, tanks, domes or similar structures.

This invention relates to a method of erecting buildings, tanks, domes or similar structures by means of pneumatic bags. More particularly the invention relates to a method of utilizing pneumatic bags to support and to raise the structure as it is assembled in a controlled sequence by workmen operating at ground level. This method is particularly adaptable to the erection of unitary structures such as Kaiser Aluminum Company geodesic domes or large diameter tanks.

Heretofore, geodesic domes have been erected by a method employing a central guyed steel tower rigged with lifting cables and winches to raise the structure progressively as its prefabricated panels have been added around the periphery at ground level. This method has required adequate tower footings to support the entire weight of the dome as it has been raised, which in most cases have no further use after the dome is in place. In addition, a large working area has been required to install the temporary guy wires for the tower.

One object of this invention is to provide a dome erection method which eliminates the need for such tower footings, and guy wires, and permits dome erection in places where the working area is limited to approximately the area to be occupied by the completed dome itself.

A further object of this invention is to reduce dome erection costs and erection time inherent in the former erection method by reducing the amount of skilled labor and erection equipment handling required.

Moreover, current practice in erecting large diameter tanks is to assemble the structure course by course from the ground up with the workmen operating from increasingly higher scaffolding as the work progresses upward, Non-productive time is obviously consumed in erecting and dismantling this scaffolding and there is a certain amount of hazard to the men working high above the ground.

Therefore, another object of this invention is to provide a safer and more rapid method for erecting large diameter tanks wherein workmen may operate entirely at ground level welding on each course as pneumatic bags progressively lift and support the partially completed structure.

Other objects and advantages of this invention will be apparent upon an understanding of the following illustrative embodiments of the invention and upon a study of the appended claims.

In the drawings:

FIG. 1, FIG. 2 and FIG. 3 are perspective views illustrating one embodiment of the method of the application as applied to the erection of a typical geodesic dome. FIG. 1 shows the operation shortly after inflation of the upper bag has begun. FIG. 2 is about midway in the erection operation, and FIG. 3 illustrates the operation as erection is completed. A portion of the completed dome has been removed to show the pneumatic bag detail.

FIG. 4 and FIG. 5 are perspective views illustrating another embodiment of the method of this application as applied to the erection of a large diameter tank. FIG. 4 shows the operation before lifting has taken place, and FIG. 5 with a portion of the tank wall cut away illustrates the operation as erection nears completion.

FIGS. 6, 7, 8 and 9 illustrate a modification of the present invention.

Geodesic Dome Erection

Geodesic domes are self-supporting structures field assembled from a plurality of prefabricated generally diamond-shaped aluminum panels. The normal procedure in erecting these domes is to add panels around the periphery of an initial center section which ultimately forms the top of the dome. This center assembly is progressively lifted vertically while additional panels are bolted around the periphery by men working at ground level until all panels are in place. Erection is completed by anchoring the lower edge of the dome to its foundation whereupon the dome becomes self-supporting and the lifting means is removed.

The present invention utilizes pneumatic bags as the aforesaid lifting means, functionally shaped to support and lift the dome without interference with the workmen assembling additional panels around the dome periphery. Referring to FIG. 1, FIG. 2 and FIG. 3, the combination of an upper spheroidal bag 1 and a lower tub-shaped bag 2 in which the upper bag nests, are used to erect a typical geodesic dome 3 having a 145 foot diameter at its lower edge and a height of 48 feet at its center. This combination of pneumatic bags when inflated in proper sequence supports and lifts the dome 3 as it is assembled and provides access for bolting on additional panels 4 around the lower periphery as erection proceeds.

The upper bag is 50 feet in diameter and 24 feet high and the lower bag is 95 feet in diameter, 33 feet high in the center and 46 feet high at the shoulders. In order to avoid excessive forces on the bags in any localized area because of the dome weight or internal pressure, the top surface 5 of the upper bag 1 is designed with the same curvature as that of the dome and supports the dome over substantially its entire surface. The shoulder surface 6 of the lower bag also bears against the dome and provides additional support. The upper surface of each bag, therefore, supports a portion of the total dome weight of approximately 39,000 pounds for the typical dome described herein.

In addition to the dome dead load of 39,000 pounds, the bags are designed for an additional load of 60,000 pounds for wind load and tie-down forces developed by control cables 8 spaced evenly around the circumference of both bags. For erecting the typical dome herein described, the bags are designed for an internal pressure of 20 pounds per square foot and in actual practice operating pressures of 15.5 pounds per square foot in the upper bag and 7.75 pounds per square foot in the lower bag have been used.

The pneumatic bag is fabricated from a flexible fabric which is substantially impervious to air and which has a high strength to weight ratio. Plastic or rubber coated nylon has been found to be a satisfactory bag material, since it possesses a tough dry surface that does not "hang-up" on protrusions, adequate strength, and exceptional resistance to abrasion.

In practicing this novel erection method, after the foundations including dome support piers 9 have been completed, the deflated bags are spread out flat and the upper bag 1 partially inflated as indicated in FIG. 1 with air furnished by blower 10 through duct 11. This initial inflation raises the top surface 5 of the upper bag to a convenient working elevation whereupon the center section of the dome is laid upon it. Since the lower bag 2 re-

mains deflated, access to the top of the upper bag is readily attained by men working at ground level. The next step is to add panels around the periphery of the center section as the upper bag 1 is further inflated as shown in FIG. 2, the lower periphery being maintained at a convenient height for men working at ground level. Upward movement is controlled by means of control cables 8 evenly spaced around the bag circumference and anchored to manually operated griphoists 12 featuring unlimited cable travel. Operation of the griphoists 12, playing out additional cable, is coordinated with bag inflation so as to maintain close control over the bag and the rate of dome elevation.

At a predetermined dome diameter, inflation of the lower bag 2 commences with air furnished by a second blower 13 and duct 14 indicated in FIG. 3, while panels are continuously added around the dome periphery maintained at convenient working level. Upward movement of the lower bag 2 also is controlled by evenly spaced control cables 8 anchored to griphoists 12.

Inflation of the lower bag 2 and addition of panels continues after the upper bag 1 is fully inflated until all panels are in place; whereupon the dome terminal panels 15 are bolted to the foundation piers 9. The dome is then self-supporting and the pneumatic bags may be slowly deflated and removed.

In this manner it has been possible to erect geodesic domes of the size described herein in approximately 22 hours with a 38 man crew operating on a controlled erection schedule permitting the labor force to be augmented as the addition of panels increases with the development of greater dome periphery. The bags are easily handled and upward movement well controlled with no "roll" even in moderately strong winds.

FIG. 6 illustrates in cross section a geodesic dome 3 being erected by the present method using bags of a modified configuration. A series of concentric open-ended tube-shaped bags 16 and 17, respectively, support the dome structure only at preselected circumferential support points. Successive bags of increasing diameter are utilized as the total diameter of the dome is enlarged during assembly.

The dome itself and the foundation or ground 18 close the ends of the bag. The end of each bag is provided with a reinforced terminal ring 19*a* and 19*b*, respectively, fabricated of steel or similar rigid material. The upper terminal ring 19*a* is secured to the dome structure, and the lower terminal ring 19*b* is bolted to the foundation, as illustrated in FIG. 7, by metal clips 20 and anchor bolts 21. The periphery of each end of the bag adjacent to the terminal ring is provided with a seal flap 22, more clearly shown in FIG. 7. The internal air pressure in the bag forces this flap against the joint between the terminal ring 19*b* and the foundation 18 thereby making a practically air-tight seal.

A seal of the joint between the dome and terminal ring 19*a* is effected in a similar manner. With this bag design the dome structure must be practically air-tight, or a loose fabric sheet is extended over the upper end of the bag, to complete the pneumatic enclosure.

Tank Erection

The pneumatic bag erection method is also adaptable to the erection of large diameter tanks. For such an application, either a single cylindrically shaped bag or an open-ended tube shaped bag is used. In addition to considerations mentioned hereinabove, the fabric must be protected from welding slag incident to welded tank construction. This is done by means of portable metallic screens or shields at each welding station.

A single cylindrical bag 23 with flat ends conforming to the shape of the tank structure is utilized as illustrated in FIG. 4 and FIG. 5, or, as an alternative, an open-ended tube shaped bag is used as illustrated in FIG. 8.

Applying the foregoing method to tank erection, the first step is to assemble and to weld together the top plates 24 and the top shell course 25 of the tank 26 as indicated in FIG. 4. This is done on temporary scaffolding or raised supports 27 so that the pneumatic bag or tube may be inserted thereunder. Uniformly spaced lugs 28 are welded around the perimeter of the top of the tank to which cable bridles 29 are fastened and interconnected to control cables 30 anchored to manually operated griphoists 31 featuring unlimited cable travel.

The bag 23 is then inserted under the assembled top plates 24 and the top shell course 25, and the bag is progressively inflated with air furnished to the bag by a centrifugal blower 32 through duct 33 thereby raising the partially fabricated tank structure 26. Upward movement is limited by control cables 30 as described hereinabove. The tank structure 26 is raised until sufficient clearance is provided for assembly and welding on the second shell course 34 shown in FIG. 5 by welders operating entirely at ground level.

This procedure of progressively raising the tank structure and welding on a new shell course continues until the final shell course 35 is almost completely in place whereupon the pneumatic bag 23 is deflated slightly thereby resting the bottom course on the tank foundation. The bag is then completely deflated and removed through space provided therefor in the bottom shell course. After the bag 23 has been removed, the tank shell is welded to the tank floor plates which are inserted through a manhole or the opening in the lower shell course 35 through which the pneumatic bag 23 has been removed. Alternative, the tank floor may be assembled and welded together first with the tank roof and shell erected on top by the aforesaid method.

For additional control of the tank as its height increases, intermediate control cables 36 are provided around the tank circumference at suitable elevations.

FIG. 8 illustrates in cross section a tank being erected with a modified tube-shaped bag structure. Here the tank top 24 and the tank foundation 18 are used to complete the pneumatic enclosure in a manner similar to the modification illustrated in FIG. 6.

The illustrated bag design is generally adaptable to erecting any shape of unitary structure and comprises a plurality of rectangular fabric sections 37 laced together, as at 38 and 39, to form a bag assembly of any desired shape. The edges of each section 37 are provided with a reinforced terminal bead 40. The beads 40 of adjacent sections are laced together manually as snugly as possible and the various joints between these adjacent beads are made air-tight. For this purpose seal flaps 22 made of bag material or other fabric are secured to the bag along the beads 40 as is more clearly illustrated in FIGS. 7 and 9. Internal air pressure forces the seal flaps 22 against the joint to effect a practically air-tight seal.

The obvious advantage of this modification is that standard bag sections may be laced together to form a bag of any desired shape and that both the foundation and parts of the unitary structure itself are used to complete the pneumatic enclosure so as to reduce the amount of bag material required in a particular application.

In the foregoing illustrations the pneumatic bag method is applied to the erection of large diameter tanks and similar unitary structures minimizing scaffolding requirements and permitting all welding to be done at ground level.

In the practice of this method, it has been found advantageous to provide an inspection opening in the pneumatic bag or bags. Because of the low pressure used, a man may enter the bag through an inspection opening to check areas of contact with the dome or tank and to repair any damage which might occur, notwithstanding the fact that the bag is under load and pressure.

Various modifications of the present invention may be obvious to those skilled in this art without departing from

the scope of this invention; therefore, the invention is not to be construed as being limited to the illustrative embodiments disclosed but is defined by the appended claims.

I claim:

The method of erecting steel tank structures by means of pneumatic bag comprising the steps of assembling the top and upper shell course of said tank; placing a pneumatic bag thereunder and inflating said bag so as to support and raise said top and upper shell course assembly sufficiently to permit assembly of a second shell course; controlling upward movement thereof by cable means interconnecting said top and the ground; welding in place said second shell course; progressively inflating said pneumatic bag and assembling additional shell courses until the tank shell is complete; providing an opening in said tank shell for bag removal; deflating and removing said bag; and then welding a tank bottom in place.

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