

July 10, 1934.

E. E. DILLMAN

1,965,736

METHOD OF TANK CONSTRUCTION

Filed Jan. 26, 1933

5 Sheets-Sheet 1

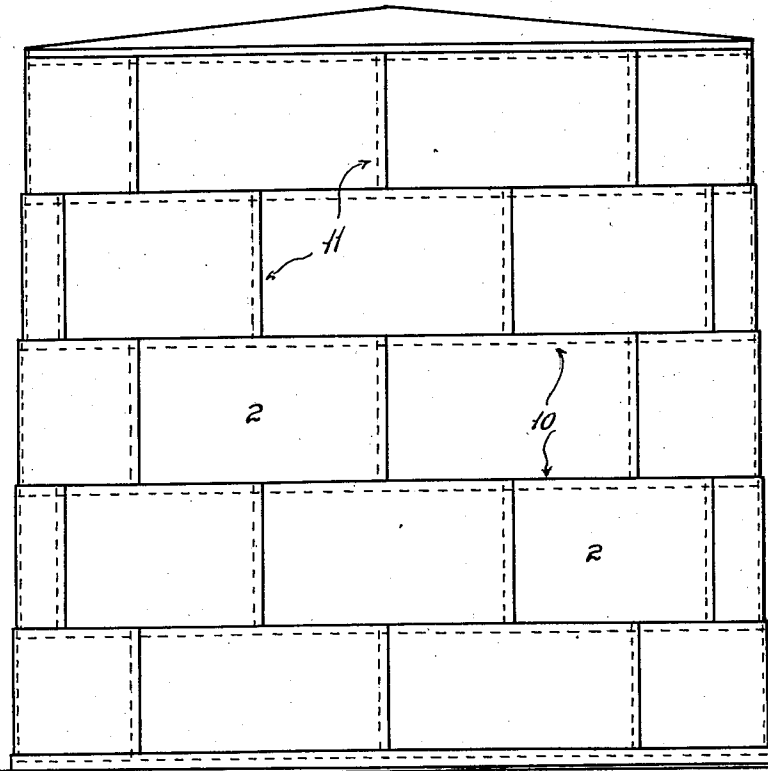


Fig. 1.

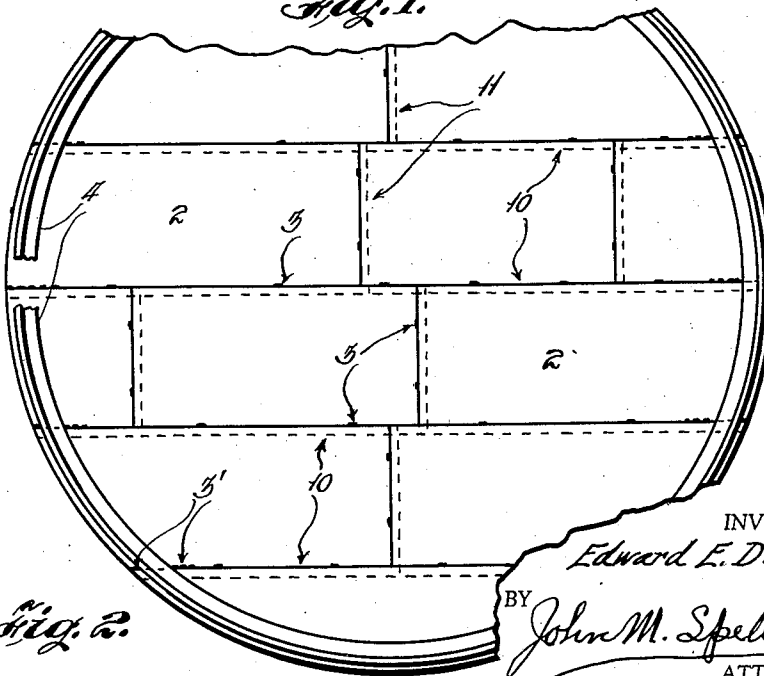


Fig. 2.

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July 10, 1934.

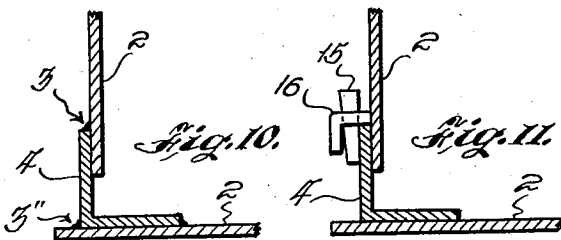
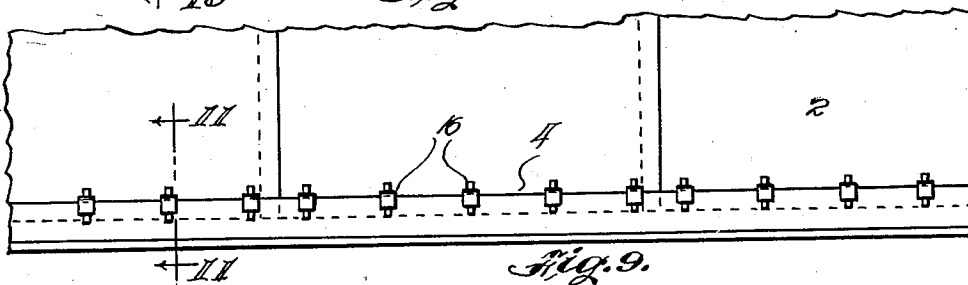
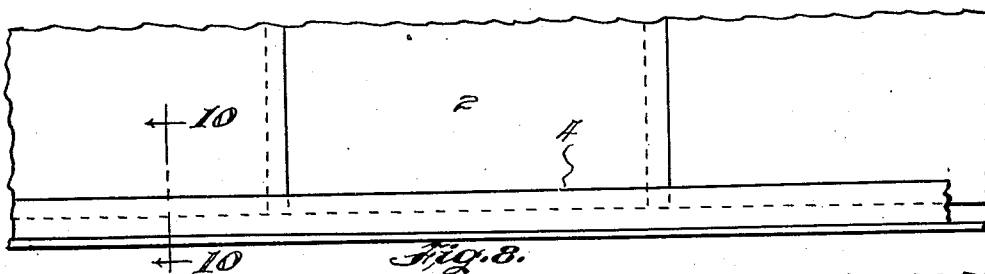
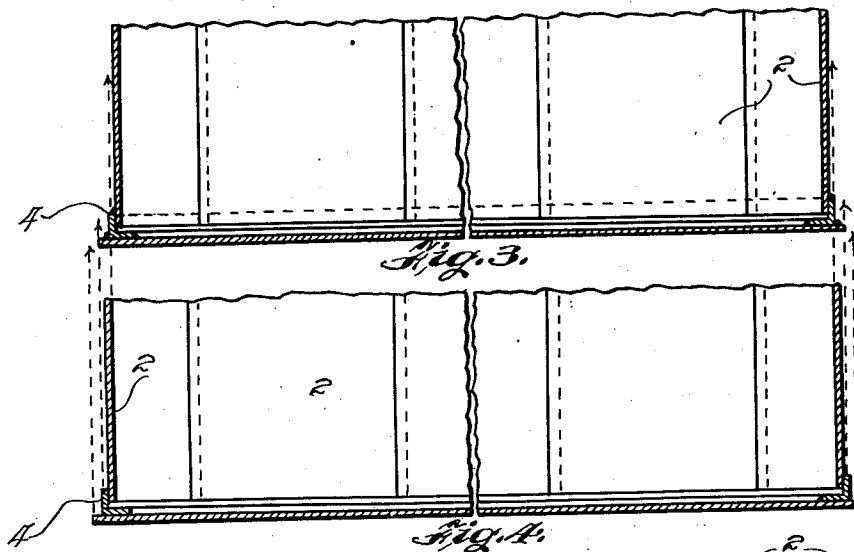
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5 Sheets-Sheet 2



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METHOD OF TANK CONSTRUCTION

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5 Sheets-Sheet 3

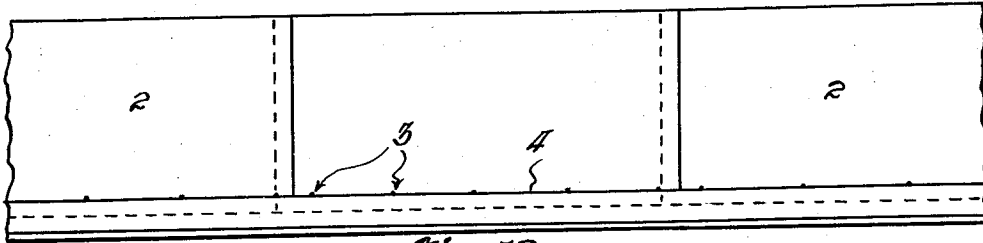


Fig. 13.

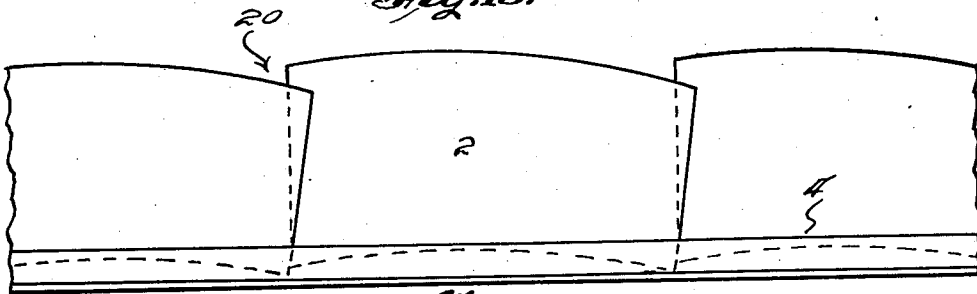


Fig. 14.

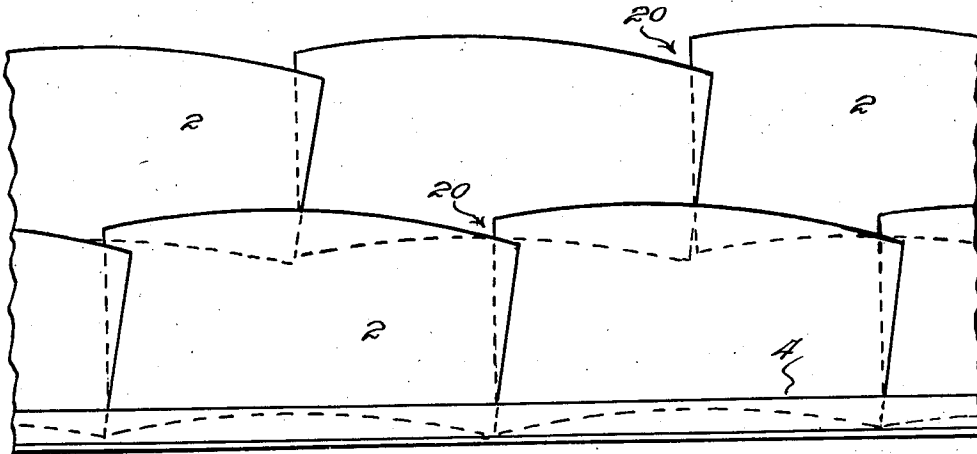


Fig. 15.

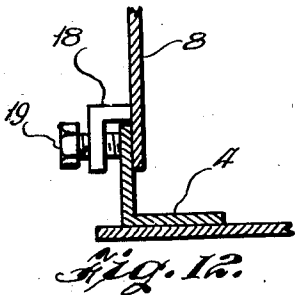


Fig. 16.

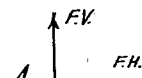


Fig. 17.

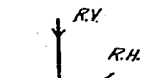


Fig. 18.

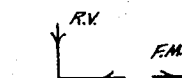


Fig. 19.

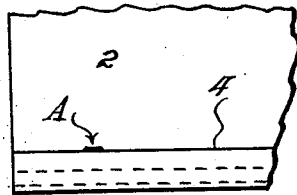


Fig. 16.

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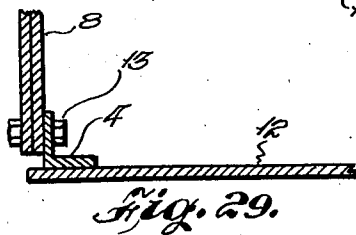
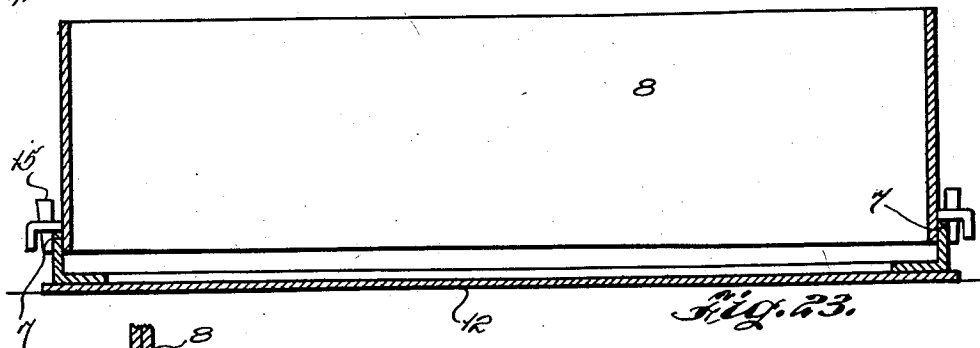
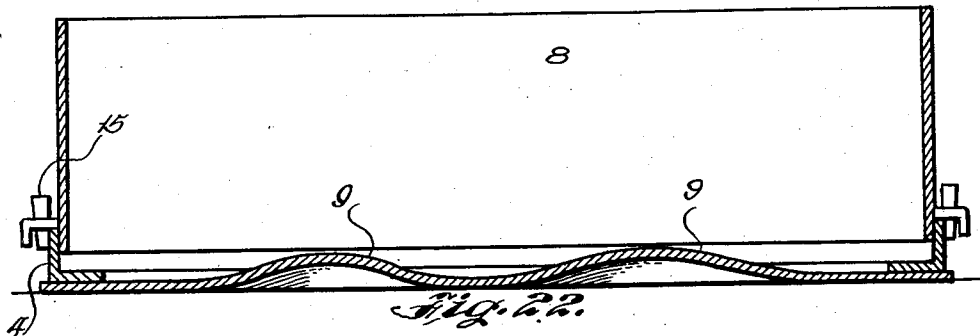
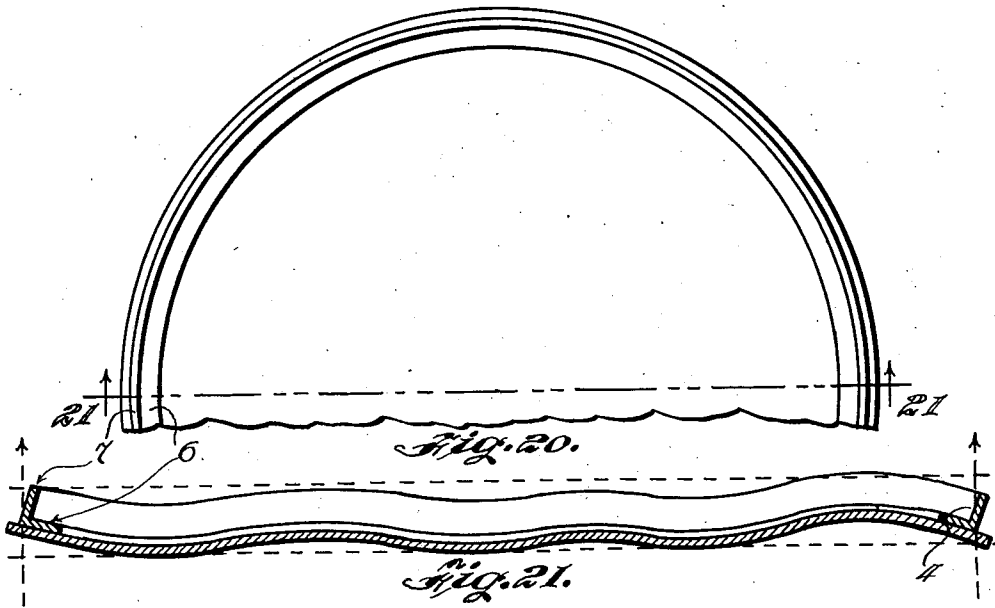
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METHOD OF TANK CONSTRUCTION

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5 Sheets-Sheet 4



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METHOD OF TANK CONSTRUCTION

Filed Jan. 26, 1933

5 Sheets-Sheet 5

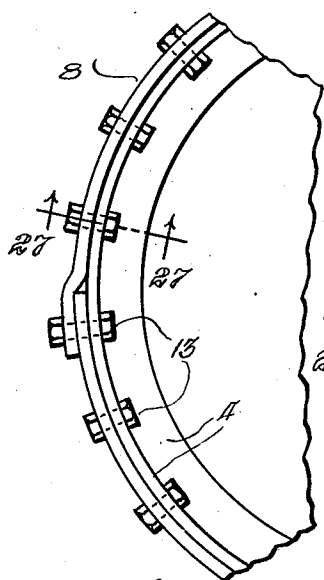


Fig. 24.

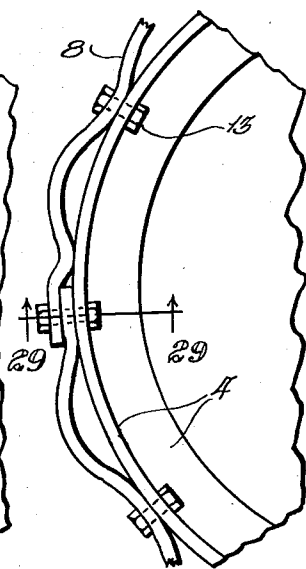


Fig. 25.

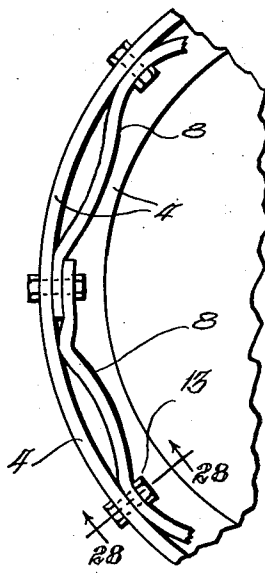


Fig. 26.

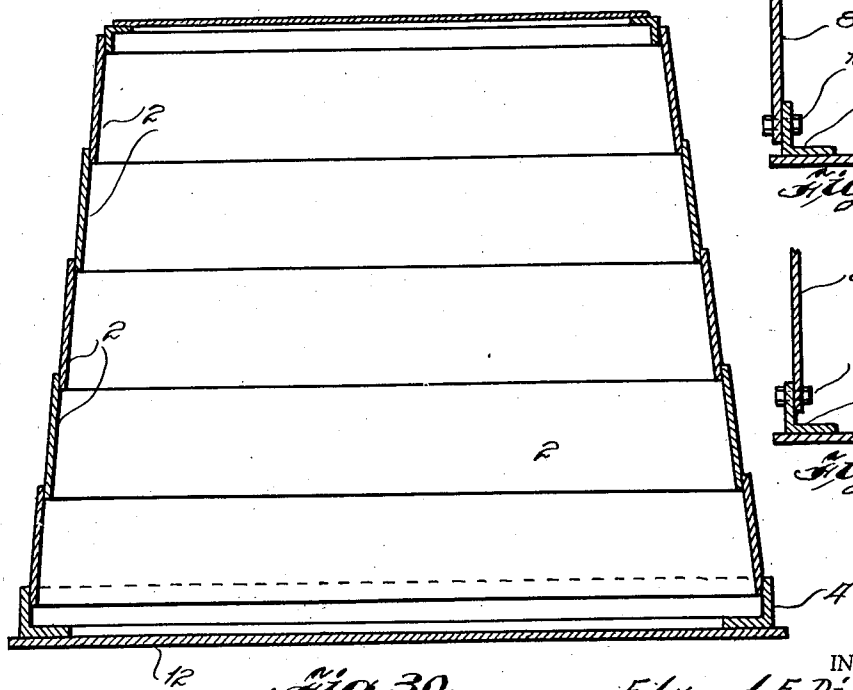


Fig. 30.

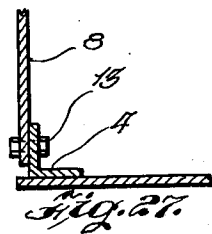


Fig. 27.

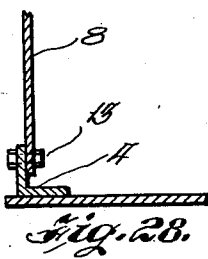


Fig. 28.

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UNITED STATES PATENT OFFICE

1,965,736

METHOD OF TANK CONSTRUCTION

Edward E. Dillman, Dallas, Tex.

Application January 26, 1933, Serial No. 653,597

7 Claims. (Cl. 29—148.2)

This invention relates to the construction of welded metal containers, such as oil tanks, water tanks or containers of this nature for any substance.

One of the objects of the invention is to provide an improved method and means for putting together the metal plates of a tank by lap welding or a modification thereof, and in such a manner that the plates will be so enabled to adjust themselves to changes due to welding that the finished structure will be symmetrical, structurally sound, and adhere to its designed shape.

In this connection another object of the invention is to provide a method whereby the movement of the plates or members of a tank can be controlled during the welding of the tank, and to prevent them from assuming a curved shape.

Another object of the improved method and means is to maintain the plates in contact at all times and in their assembled relations and to overcome the inherent shrinkage of a welded container, resulting in a symmetrical tank.

A further object of the method is that a bottom angle may be used in constructing a tank or container by preventing the stressing of the bottom angle during the welding method. Other important objects will be apparent hereinafter.

The invention may be readily understood from a perusal of the following detailed description, taken in connection with the accompanying drawings, forming a part of this specification, and in the drawings:

Figure 1 is a side elevational view of a welded tank constructed in accordance with the improved means and method.

Figure 2 is a plan view of a tank bottom including the bottom angle member of the tank.

Figure 3 is a vertical sectional view through the tank bottom, bottom angle member and a portion of the first ring or assemblage of plates, the view being in broken formation for convenience of illustration.

Figure 4 is a view similar to Figure 3, but showing the tank parts in assembled position before welding, Figure 3 illustrating the tank after welding with consequent reduction of its diameter.

Figures 5, 6 and 7 are fragmentary detail sectional views respectively of modifications of overlapped construction susceptible of use with the method.

Figure 8 is a side elevational view in part of a tank wall, bottom angle member and the tank bottom, after welding, or a developed bottom angle and first course in welded position.

Figure 9 is a view similar to Figure 8, but

showing the parts prior to welding, with the use of devices for clamping the member in assembled position.

Figure 10 is a cross-sectional view on line 10—10 of Figure 8, and Figure 11 is a cross-sectional view on line 11, Figure 9.

Figure 12 is a detail view of a clamping device for holding the plates in assembled position during the welding, the device being related but different from the device shown in Figure 11.

Figure 13 is an elevational view of the first course of shell plates in assembled position with developed bottom angle, before welding.

Figure 14 is a similar view to that of Figure 13, but showing the plates after the welding of the horizontal seams.

Figure 15 is a view similar to Figures 13 and 14, but illustrating developed bottom angle and first and second course of shell plates after welding.

Figures 16 to 19, inclusive, represent diagrammatically the action and result of expansion forces and movements thereof.

Figure 20 illustrates in part the plan view of a tank bottom and its angle member, Figure 21 being a cross-sectional view on line 21—21 of Figure 20, these views for the purpose of illustrating faulty construction to be overcome.

Figures 22 and 23 are vertical sectional views of a tank bottom, angle member and the first course of shell plates in position before welding, the latter (Figure 23) showing the completed bottom with the buckling removed.

Figures 24 to 29 inclusive are shown to illustrate tank construction not employed in this method and to make clear the purpose of this invention,—Figures 24, 25 and 26 representing plan views in part of a tank bottom and part of the tank shell, and Figures 27, 28 and 29 being cross-sectional views of Figures 24, 25 and 26, respectively.

Figure 30 is a sectional view of a tank which has resulted from faulty construction, causing abnormal reduction of capacity and lack of symmetry—the view being shown for the purpose of making clear the improved method and means to be now more particularly described in detail.

In Figure 1 is shown a tank constructed in accordance with the improved method and in which the seams are overlapped or in which these seams are a modification of overlapped construction such as is shown in Figures 5, 6 and 7. Figure 1 shows the construction of a tank as carried out in the improved method and the true relation of the plates 2 to each other in order that the tank or

container will be symmetrical in shape. The courses, rings, or sections of a tank, to be thus symmetrical, must be in a true vertical plane and the top of each ring, course or section, that is each horizontal seam, must lie in a true horizontal plane, or in the planes as required by the shape and form of the container. To obtain this result and at the same time produce a structurally sound tank is the object and purpose of the method and means herein described.

In constructing the improved tank and as shown in Figure 2 the bottom plates are held in position by light tack welds 3, after being properly assembled with the bottom angle 4, also similarly tack welded to the bottom plates 2. The only continuous welding or strength welding done on these members at this time is the welding of the overlapped seams that fall under the bottom angle as at 3'. To these seams there is no access for welding after the bottom angle is placed in position. This plan view thus shows the relative position of these members in assembled relation before any strength welding takes place. Figure 4 shows the relative position of the plates 2 which constitute the shell of the tank in assembled position prior to welding, while Figure 3 illustrates the parts after welding, the dotted lines and arrow-heads indicating diameter before and after the welding has been done.

As previously stated, to provide a symmetrical tank, the walls or sides must be in a vertical plane and the horizontal seams in a true horizontal plane. To accomplish this, the shrinkage, that is, change in diameter, of the first ring, course, or section, must be controlled. A certain portion of this shrinkage comes from the welding of the bottom plates to each other. This is relatively small, however, as the major portion of the shrinkage is caused by the welding of the bottom angle to the bottom plates.

The welding of a circular section, such as a bottom angle or ring, to a flat plate, such as the bottom of a container such as shown in Figures 3 and 4 causes a contraction of the diameter of this circular section. If the bottom is a complete unit, that is the equivalent of a solid plate, the result of the change in diameter referred to above would be that the bottom will rise up from the foundation at some points, since there is more area of plate in the bottom than required by the smaller diameter of the ring. Since this change depends on conditions such as heat of the welding arc and thickness of the respective members, the exact amount of shrinkage cannot be determined before welding takes place. The procedure and methods of welding and assembly must compensate for this unknown factor.

Assuming that the bottom of the tank is in one piece, the condition that will be found in the bottom after welding is: the bottom plates will not rest evenly on the foundations after the welding takes place. The strength of the bottom to withstand a contractive stress applied at the outside edge of the diameter is not sufficient to keep the plate from rising off of the foundation. These plates are thin and the section modulus in a horizontal plane is small. As a result of this condition, the plates must bend from this contractive stress, since the bottom is in one integral unit. As this plate is circular in shape, the buckles that appear will be in different and varied positions. In some cases they will be under the bottom angle and in others towards the center of the bottom.

As a result of this buckling condition of the bottom under the bottom angle, the top edge 6 of

the bottom angle 4 would not lie in a horizontal plane, and the upstanding leg 7 of the angle would be in or outside of a vertical plane as indicated by the dotted lines and arrow-head in Figure 21. This condition can only result in a tank that is not symmetrical and in which buckles will appear in the shell.

To overcome the condition shown in Figures 20 and 21, which is caused by the buckling of the bottom plates, the following method and procedure is carried out. In Figure 2 is shown the bottom, composed of the plates 2 and the bottom angle 4 in place in the assembled position. These members are held in such position by the light tack welds 3 as previously stated. To the bottom angle 4 is attached the first ring or section, that is the plates 2 in Figure 4. The first continuous weld is the weld connecting the bottom angle 4 to the bottom plates 2. This is shown in detail in Figure 10. Attention is called to the fact that all plates in the bottom and the bottom angles are maintained in position by light tack welds 3. It will be assumed that a satisfactory method of attaching the first ring or course to the bottom angle is used. This ring is attached before the weld 3' is made, see Figure 10. As the bottom plates are particularly weak against a contractive force applied at the extreme edge, the vertical force of the first ring, course or section, that is, weight, will hold the angle on the foundation. This will be clear from Figure 22, the first ring being indicated at 8. This arrangement forces the buckles 9 to appear in the bottom away from the edges. At the completion of the welding of the bottom angle to the bottom plate, all contraction from this welding has taken place and has resulted in buckles in the bottom.

The bottom longitudinal seams 10 are now welded from the inside of the bottom angle to the center of the bottom. As these seams are welded, the light tack welds 3 break or are mechanically broken, which allows each plate to shift slightly, thus compensating for the change in diameter. This shifting can readily take place, as the cross seams 11 are not welded until the longitudinal seams 10 are welded. This method results in a flat bottom 12 resting evenly on the grade, and having the top edge of the bottom angle in a horizontal plane and the upstanding leg thereof 7 in a vertical plane as shown in Figure 23.

In the above description of the method used to procure a flat, level bottom and bottom angle, it was assumed that a satisfactory means of connecting the first ring to the bottom angle was used. A perusal of Figures 8 and 9 will show the first and primary condition to be met if a safe and structurally sound tank is to be secured. Figure 9 shows an elevational view in part of the first ring of a tank attached to the bottom angle in an assembled and developed position. Figure 8 shows that the bottom and the bottom angle have been welded. This is a developed section and has the change in circumference as the result of this welding. As the diameter of the bottom becomes smaller, the circumference becomes smaller.

Let it be assumed that the first ring is retained in position by some means that prevents a lateral movement of the plates, that is, prevents the sliding of the members by each other as the circumference becomes smaller. This condition would be secured if holes were punched in the angle and plates so that these holes would match bolts or rivets used to hold the plates in position. See Figure 24. The bolts are indicated at 13 and 8 150

represents the first ring. This arrangement would result in the condition shown in Figure 25 or in Figure 26, depending upon which type of bottom angle construction is used. If the construction shown in Figure 25 is used, the plates must buckle between the bolt or rivet holes or hold the bottom angle to the assembled diameter of the bottom ring. If the construction shown in Figure 26 is used, the plates must buckle between the plates, as shown in the drawings. The position the plates will take depends upon the strength to withstand buckling that the first ring plates will have. As the plates must buckle against the arch of the plates, and if the plates are relatively thick and the holes relatively close together, the condition shown in Figure 24 will probably maintain. If the condition is as shown in Figure 25 or Figure 26, buckles will appear on the first ring and the ring will not have the plates in vertical plane, and the top edge of the plates will not be in a horizontal plane. In all cases in which the bottom angle is outside of the first ring, the symmetry of the tank will not be affected, but the safety of the structure would be affected. Since the tank must maintain its assembled diameter, and as it is assumed that the first ring is rigidly fixed to the bottom angle, stresses will be set up in the bottom angle. The bottom angle will tend to contract as it is welded. It must contract against the first ring, which is fixed in diameter because of the bolts 13. The resistance of the first ring to contraction will cause the bottom angle to maintain its position as assembled. Since this contraction of the bottom angle does not take place, a stress must be set up, either in bottom angle weld or the bottom angle. If this stress is in the bottom angle, it will be a tensile stress. As the stress in the bottom angle from the loads in the tank are tensile stresses, the net result of the stress in the bottom angle from welding is to increase the stresses by that amount. Consequently, greater stresses are built up than called for in the design.

That this has been the case and the result of such design has been established by bottom angle failures where welded bottoms have been attached to riveted shells. In the case of riveted shells and welded bottoms, this condition has been accentuated to a maximum degree, as the shell diameter must be constant and the diameter of the bottom and bottom angle after welding must be restrained to this degree.

To overcome the condition described above, a clamp device is used that will hold the plates temporarily in the correct position. Any clamp device used must hold the members in contact through friction so that the members can slide by each other to compensate for the smaller diameter after welding and the smaller circumference. One type of such clamp device is shown in Figure 11.

It is imperative that the members be free to move by each other in order to compensate for the inherent change in diameter due to the contraction of the bottom angle or section when it is welded to the bottom plates. The clamp device must not allow the members to get away from the assembled position and must hold the members in contact. This result is secured through frictional contact and as there are no means of connection through the members, they can slide by each other as contraction takes place. Since the frictional force exerted by the clamp can be relieved by loosening of the wedge member 15 of the clamp body 16, if necessary, and since all the vertical seams are free to take up this

contraction of the diameter and ring, stresses cannot be built up in any of the welds or members. The members will be constantly in contact and will remain in their assembled relation.

Reference to the drawings, Figures 13 to 15 inclusive, illustrates another necessary attribute of a fitting up device. Figure 13 shows a developed elevation of the first ring of a tank before welding. The plates 2 in this view are held in position by a device that does not rest against the edge of the horizontal seam, see Figure 12, as does the device shown in Figure 11. This device consists of an angular body 18 and a screw bolt 19 for frictionally holding the bottom angle and the first ring together. Or let it be assumed that any device may be worked out that meets the requirements of the conditions described, and does not rest against the horizontal seam, either on the inside of the shell or wall or on the outside. When the horizontal seam is welded there will be a movement of the plate that is being welded, which will cause the plates to become curved as at 20, Figures 14 and 15, on the longitudinal edges. Figure 15 shows the same condition in the developed section of rings one above the other, or sections, of the plates 2. By a ring is meant a circular row of plates 2. All other rings would be similarly conditioned. The result of this movement would cause the plates to shorten and result in the top of the rings falling inside of the vertical plane. The result of this condition would be that as the top of each ring fell inside of the vertical plane, the finished tank would assume a shape similar to that shown in Figure 30. This form of tank would be impractical because of the reduction in capacity, its lack of symmetry and the difficulty encountered in placing the supporting steel for the roof.

This curving of the longitudinal edges of the plate is caused by the contraction of the plates along the edges being welded. The heating caused by the welding tends to make the plate expand; but since this heat is localized at the point of welding and is gradually diffused into the colder portions of the plate, this expansion takes place against cold metal. This cold metal is very resistant to deformation. As the metal at the point of welding is in a molten state, this expansion causes the hot metal, which is much less resistant to a given force, to deform and the molecules to become closer together. The edge of the plate or member becomes shorter and causes the plate to take a curved position. This condition is inherent in the welding process.

In Figure 16 is shown a portion of one plate and a portion of the bottom angle removed from the shell or wall of a tank. Welding has taken place at the point "A". Figure 17 shows diagrammatically the expansion forces caused by the welding resolved into vertical and horizontal forces. Similarly to Figure 17, Figure 18 shows the resultant movement of these forces. As the bottom angle is restrained by the foundation, all the movement will be in the plate, resulting in a downward and horizontal movement, as shown by the resultant. This movement will result in a deformation of the plate.

If a force is introduced that will oppose the vertical resultant R—V in Figure 18, the downward movement would be restrained and all movement would be in a horizontal direction. Figure 19 shows graphically the introduction of such a force at the point "A". The bottom angle is re-

strained from a vertical movement by the foundation. Any other ring or course after the lower horizontal seam is welded would also be restrained from a vertical movement, as any force tending to cause such movement would be transmitted to the foundations through the lower rings and bottom angle. This force FC as shown in Figure 19 requires that any device used be so designed and placed that any vertical force will be transmitted to members that are fixed in position.

It becomes apparent that tack welding the plates together would satisfy the condition that a vertical movement be restrained. This method of erection would not satisfy the condition that the members be allowed to slide by each other as the contraction due to welding takes place. A condition similar to that shown in Figures 25 and 26 would result if such a method was used. Such a condition would jeopardize the structural integrity of the tank and must be avoided.

A device, to be effective, must hold the plates together by friction, and this frictional force must be readily adjustable so that a horizontal movement, vertical movement or any movement as required by the shape and type of container can readily take place. This movement will compensate for the change in diameter that takes place when the container is welded. A device must rest on the next lower member or be so designed that a vertical movement of the member being welded is restrained, and thus prevent a curvature of the member or plate being welded.

In order to make effective the methods and devices described the vertical seams are not welded until all the horizontal seams are welded. In welding the vertical seams last, any movement of the members will be restrained to a horizontal movement, which will be compensated for by the open, unjoined seams. The welded horizontal seams will restrain the vertical seams to the assembled position and insure a symmetrical tank.

The method herein described and illustrated when used with the general type of clamping device shown in Figure 12 will result in a symmetrical and structurally sound container. The invention is intended to embrace variations in the method of lap welding of tanks as stated and the clamping means may also be altered and modified to an extent in keeping with the appended claims.

What is claimed as new is:

1. A method of constructing a multi-plate tank which comprises assembling plates in over-lapped position to form a bottom, temporarily uniting the plates by tack welds, placing a bottom angle iron on the plates, retaining the bottom angle iron in position by light tack welds, attaching a ring or section of wall plates to the bottom angle iron, permanently welding the bottom angle iron to the bottom plates, permanently welding first the longitudinal seams of the bottom plates, then permanently welding the cross seams of said plates.

2. A method of making a multi-plate structure, which comprises assembling plates in rows and in over-lapped position at all meeting edges, each row comprising a plurality of plates, temporarily uniting the plates by light tack welds, placing a curb member on the plates, securing the curb member against distortion by the buckling of the plates when the curb member shrinks in diam-

eter, so that the buckles will be removed from the perimeter of the assemblage, inwardly toward the center thereof, permanently welding the curb member to the plates, permanently welding the seams that run in one direction, and then permanently welding the cross seams to eliminate the buckles in the assemblage.

3. A method of constructing a multi-plate tank according to claim 6, which consists of adding additional rings or sections to the first ring or section attached to the curb member or bottom angle iron by means of friction clamp members to permit lateral movement of the plates when welded together and to prevent the plates from assuming a curvature, and welding first the longitudinal seams of the side plates, then welding the cross seams of said plates.

4. A method of constructing a multi-plate tank which consists of assembling bottom plates in over-lapped relation, tack welding the plates, placing permanent welding in the seams of the plates which will come under a curb member, seating a curb member with attached first ring side plates on the bottom plates, permanently welding the curb member to the bottom plates, welding the longitudinal seams, and then the cross seams of the bottom plates; then using frictional means for holding successive side wall sections of plates to said first ring of plates, to prevent vertical movement of the member being welded to avoid curvature of the side plates, and then welding first the horizontal seams and then the vertical seams to form the completed tank.

5. A method of constructing a multi-plate tank which comprises attaching by means of frictional clamps the plates of the side wall sections or rings to a curb angle on the assembled bottom plates of the tank, prior to the welding of said bottom plates, then similarly and by means of frictional clamps attaching the plates of successive side wall sections to the next lower adjacent side wall section, said clamps being adjustable to permit adjustment of the frictional force holding the plates in contact, in order that the plates may adjust themselves to the final dimensions of the tank after welding.

6. A method of making a hollow sheet metal structure which comprises attaching by means of frictional clamps the plates of a side wall section or ring to a lower section or ring, then similarly and by means of frictional clamps attaching successive side wall sections each to the next lower section, said clamps being adjustable to permit adjustment of the frictional force holding the plates in contact, in order that the plates may adjust themselves to the final dimensions of the structure after welding.

7. A method of making a hollow sheet metal structure which comprises attaching by means of frictional clamps the plates of a side wall section or ring to a lower section or ring, then similarly and by means of frictional clamps attaching successive side wall sections each to the next lower section, said clamps being adjustable to permit adjustment of the frictional force holding the plates in contact, in order that the plates may adjust themselves to the final dimensions of the structure after welding, welding the circumferential seams and finally welding the cross seams.

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