METHOD OF BUILDING CONCRETE OIL STORAGE TANKS

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1. This invention relates to the art of constructing concrete tanks and storage containers for the storage of petroleum oils and other fluids, and more particularly to a method for constructing reinforced concrete storage.

2. The method of the present invention is particularly adapted to the construction of tanks of relatively large size for the storage of petroleum oils, especially for the construction of bomb-proof storage. However, the invention is not restricted to the construction of oil storage tanks, but may be applied to the building of containers for other purposes.

3. The present application is a continuation-in-part of the applicant’s pending application Serial No. 340,281, filed June 13, 1940, for “Art of constructing metal liquid storage tanks.”

4. In that application it was pointed out that the petroleum industry as a whole presents a huge problem in liquid storage; the volume of crude oil to be stored, together with the volumes of finished and partially finished products results in a liquid tankage demand that probably is the largest of any single industry. While run-down and work tanks around a refinery are relatively small, many of the field storage tanks are among the largest employed by the industry. For example, tanks having a diameter of approximately 120 feet and a height of approximately 50 feet, are common for storage purposes, although many larger tanks are in use. For refinery operations many smaller tanks are employed, although these usually are large in comparison with those deemed large in other industries.

5. The pending application discloses and claims a method for constructing storage tanks for liquids, for example, sheet metal storage tanks in which sheet metal rings usually composed of a plurality of metal plates are erected in series, one upon the other, and secured together to make a tank of the desired height by the use of the steps providing a floatable member such as a floating deck or roof or raft of substantial size, with suitable erection equipment thereon, within the area to be surrounded by the tank shell or wall, the floatable member being adapted to float on a liquid to be introduced into the lower portion of the tank after that portion has been erected, then erecting the lowermost or first ring or rings of the tank in a liquid-tight manner around such floatable member by attachment to a sheet metal bottom, introducing liquid into the erected ring or rings to float the floatable member therein and bring it to the desired height for use as a platform from which to work in the erection of the next ring or rings of the tank, and repeating the operation of introducing liquid to elevate the floatable member after the erection of each successive ring or rings in liquid-tight manner to the next lower ring, until a tank wall or shell of desired height has been erected.

6. The pending application further discloses the fact that the floating member used inside the tank, may, in the case of a tank to be provided with a floating roof, actually be the floating roof itself which is intended to be left in the tank and which is usually only slightly smaller in diameter than the inside diameter of the tank. And that in other cases, the floatable member may comprise one or more suitably sized rafts or floats which can be used as a platform to carry erection equipment, materials, and workers.

7. Various proposals have been made for the construction of concrete storage tanks for petroleum oils and other liquids, but in the usual construction procedure large expenditures are required for scaffolding, forms and bracing. The matter of forms for erecting a concrete tank of substantial size is an enormous problem. Scaffolding not only must be maintained and extended with a minimum of interference with the concrete workers, but must be safe under all conditions of loading, and all inside scaffolding must be removed before the tank can be tested or used. Seepage or other defects which may be discovered after a test on the completed tank may necessitate the re-erection of scaffolding and platform to make repairs. In general, it may be said that one of the primary costs in the erection of concrete storage tanks by present methods is tied up in scaffolding, bracing and forms and their erection.

8. Furthermore, when it is desired to construct a concrete storage tank for volatile liquids such as gasoline, using present methods and provide the tank with a floating roof, such roof must be constructed after the tank has been completed and obviously with great difficulty.

9. Having in mind the various proposals and practices now employed in the building of concrete storage, the primary purpose of the present invention is to provide an improved method of concrete storage construction which will materially reduce the cost of construction.

10. Another object of the invention is to provide an improved method of construction which will increase the comfort and safety of the workers and avoid the usual hazards involved in working from scaffolds.
A further object of the invention is to provide an improved method of construction in which the container wall is simultaneously built-up and tested for defects and leakage.

Another object of the invention is to provide an improved method of constructing concrete storage which will eliminate the necessity of using scaffolding and the expense involved in scaffolding equipment and its erection.

A further object of the invention is to provide a method of construction which will materially simplify the forms and other equipment required.

Another object of the invention is to provide an improved method for constructing concrete floating-roof storage tanks for liquids in which the floating roof is floated on water or other liquid and used in the construction process.

A further object of the invention is to provide an improved method for constructing storage containers which will materially cut down delays during construction and actually reduce the construction time.

A still further object of the invention is to provide an improved method for constructing concrete containers which will avoid the fire hazard involved in the use of scaffolding, and keep the concrete wet.

Accordingly, the present invention comprises certain improvements in the art of constructing concrete storage for example tanks for liquids in which the tank wall is erected by successively pouring a plurality of courses or rings of concrete upon the other until a tank wall or shell of desired height has been built.

The improvements of the present invention preferably include the steps of providing a floatable member or members such as a floatable deck, or roof of substantial size within the area to be surrounded by the tank wall, as for example on a concrete foundation or concrete bottom for the tank, providing and setting a wall form around said member which may be held by and braced from said member, pouring the lower portion of the tank wall in said form by introducing and distributing a suitable fluid concrete mix thereinto to cast a ring of the tank wall and permitting it to set, and thereafter releasing the form from the set portion of the wall. During the pouring operation the weight of the wet concrete may be counter-balanced in part from within the tank area by introducing water or other liquid thereinto and keeping it to about the height of the wet concrete. After the concrete has set and the form released, the form is raised to a new position either by mechanical means, or by floating said member within the tank area if water has not previously been introduced. After the form is brought to the desired height, it is set in place and a new ring of concrete poured on the wall. These operations are repeated until a tank wall or shell of desired height has been erected.

The floatable member may be left in the completed tank as a floating roof, or used as a form or support on the liquid for pouring a permanent concrete roof, or for example, if made of steel or reinforced concrete it may be secured to the top of the tank wall and used as a permanent roof or as a reinforcing for a heavier bomb-proof concrete roof.

The improvements of the present invention include the testing of the wall structure for leaks and other possible defects as the successive courses or rings of concrete wall are added.

Other objects and advantages of the invention will be apparent to those skilled in the art of constructing concrete structures from the following more detailed illustrative example thereof taken in connection with the accompanying drawings in which:

Fig. 1 is a diagrammatic vertical sectional view of a concrete storage tank for liquids at an intermediate stage in its construction.

Fig. 2 is a diagrammatic broken vertical sectional view of the top portion of a completed tank showing one method of using the floating deck in providing a permanent tank roof.

Fig. 3 is a view similar to that of Fig. 2 showing another method of using the floating deck in making a permanent roof.

Fig. 4 is a broken sectional view of the tank such as shown in Fig. 1 illustrating a method for simultaneously constructing and lining a concrete tank.

Fig. 5 is an enlarged broken vertical sectional view showing one method for holding the lower edge of the inner form band against the set concrete while permitting the deck to be raised.

Fig. 6 is a broken view showing a method for hanging the hose shown in Fig. 1.

Fig. 7 is a view similar to that of Fig. 6 showing an alternative or coordinate method of setting and retaining the inner form bands.

Figs. 8 and 9 are respectively broken front and top views of the preferred form band and means for expanding and contracting the same.

Fig. 10 is a broken view of the tank wall showing one method of stepping in the outer surface of the tank wall.

Fig. 11 is a broken vertical sectional view of a portion of a column in a tank showing one method of construction.

Fig. 12 is a broken vertical sectional view of the top of a column in a tank showing a method of tying it to the deck and concrete top of the tank.

The preferred method of constructing concrete containers in accordance with the invention is illustrated in Fig. 1 of the drawings which shows a concrete tank in the process of construction.

The elements and features in this figure comprise a concrete foundation, floor or bottom, 22, and constructed portion of the tank wall, 24, all preferably reinforced with suitable steel or other metal reinforcing, such reinforcing extending from the foundation into the concrete foundation, the metal reinforcing rings as shown at 26 may be used in the outer portion of the wall. The tank or container wall may be constructed without metal reinforcing by making the wall thicker as will be understood by those skilled in the art.

After the foundation, 20, and floor or bottom, 22, have been poured and allowed to set, a floatable deck, now shown at 23, is preferably erected on the bottom, 22, or on a suitable support, not shown. The deck is preferably made of sheet steel, in the circular pan shape shown in which the upper edge has been formed to form a flange 30. The deck structure preferably includes radial steel reinforcing members 32 spot welded to the bottom plate, cross beams 34 and a platform 36 on which is mounted a single mast 38 and a boom 40. The mast, 38, is preferably centrally located and preferably gued to the edge of the deck and if desired to the ground, by guys 42 and 44 respectively, the latter guys being slacked off when the deck is raised. Instead of using ground guys, the edge of the deck may be anchored, at three, or more spaced points, by the use of anchor lines such as the one illustrated at 45, which has one end fixed to the bottom of the tank. Each line
45, which may be a cable or chain, passes through a tubular opening (not shown) near the edge of the deck 28 and around a hand winch 45 mounted on the inner edge of the deck. The anchor lines 45 and the guys 44 are principally useful to prevent wind action, and in many cases the anchor lines are more useful and convenient than the ground guys because they can be set or slackened-off directly from the deck. A concrete mix supply bucket 47 is suspended over the wall 24 from the boom 40, by means of suitable block and tackle equipment shown by way of illustration, for the purpose of supplying concrete mix to the wall.

The deck structure and equipment also preferably includes a form or forms for constructing the tank wall and suitable means for supporting the same from the deck and for setting or adjusting the position of the forms or forms. The means for supporting the forms outside the deck comprise a plurality of A-frames, one of which is shown at 48, secured to the flange 30 and each braced in upright position by means of a brace 49. Each of these A-frame includes a pair of outwardly extending brace plates 50, between which two spaced sheaves 51 are mounted, the outer of which is adjustable horizontally in the bracket plates 55 for different wall thicknesses. Separate cables 52 pass over the sheaves 51 from a winch mechanism 53, and have their ends attached to support inner and outer form bands 54 and 56. The A-frame units are preferably distributed around the deck at distances of from 30 to 40 feet, with at least three as the minimum number. The spacing will depend on the depth and thickness of the plate in the bands 54 and 56. The winch mechanism 53 may include any well-known lifting means such as a pair of independently operable hoisting drums provided with a hand operated worm and wheel drive, and suitable locking means (not shown). Each of the form bands 54 and 56 includes one or more sets of mechanism for expanding and contracting the bands, one such set being shown generally at 65 on the band 54 in Fig. 1, and in detail in Figs. 2 and 3. This equivalent mechanism is used to release the form bands from the set concrete wall section and for clamping the forms back again at the correct diameter for a new pour of concrete after they have been raised. The inner band may be braced firmly from the deck by means of an annular expansion hoes 69 or equivalent means. Jacks or other means mounted on the A-frames may also be used against the inner band 54 to aid in holding it in position.

After the deck 28 and the equipment described above, as well as other suitable and necessary equipment such as winches and motors for operating the block and tackle, has been provided, the next step in the construction of the tank is to set the form bands 54 and 56 in the desired position on the foundation 28, and then pour the lower section of the tank wall. In this connection, the deck 28 may rest directly on the concrete floor 22, or on a platform as desired. It is to be understood that suitable reinforcing (not shown) embedded in the foundation 28 may extend and preferably does extend into the wall around the tank to tie the two together. The pouring of the first section of the tank wall may be carried out with the inner form band braced from the deck while the deck remains in fixed position, or by counterbalancing the pressure of the fresh concrete against the inner form band by introducing water into the tank area through a pipe 61. If the former plan is followed the deck remains in fixed position until the concrete pour has set sufficiently, then the form bands 54 and 56 are released from the set concrete section by the use of the mechanism 55. Water is introduced into the constructed portion of the tank and the bands are released through the pipe 61 to float the deck 28 and raise the form bands to the desired height for the next course. The deck is preferably raised only sufficiently to bring the lower edges of the form bands to a point somewhat short of the top of the set wall section so that the lower portion of the forms may be clamped against the solid wall section before proceeding with the pouring of the next section.

When water is introduced to counterbalance the pressure of the fresh concrete, some concrete is first poured all around the wall so that water will not enter the forms. Then, before the introduction of water is commenced, the cables 52 are released to unwind from the mechanism 53, also cables 45 or ground guys 44, which ever are being used, and the hoes 60 is collapsed so that the deck 28 will float up freely leaving the forms in set position. Water is then introduced through the line 61 to bring the water level to and keep it about the same as that of the concrete as it is poured in the annular space between the form bands 54 and 56. As the first pour of concrete has set sufficiently the cables 52 are tightened evenly around the deck, then the form bands are released from the set concrete and elevated, preferably one at a time, to a new vertical position for pouring the next course of concrete, by operating the winch mechanism 53. The form bands are then clamped in place with their lower portions gripping the upper part of the set concrete wall section. After pouring again starts the deck is released to float up as before as water is introduced. As a pour is completed or nearly so, the introduction of water may be stopped, the deck stabilized with the cables 45 or guys 44, and the hoes 60 inflated to brace the inside form against the deck until the concrete sets. This procedure may avoid any possible give in the band 54, especially on large tanks. The use of the hose 60 gives a uniformly distributed pressure around the circular deck. The form bands 54 and 56 as indicated diagrammatically in Fig. 1, preferably comprise a plurality of steel plates having the desired curvature, or are thin enough to conform to the desired curvature. As also indicated in Fig. 1, they are fastened together by mechanism such as illustrated in Figs. 3 and 6, in enlarged detail. Both of the forms 54 and 56 preferably comprise a plurality of overlapping sheet steel plates so that each form may be contracted and expanded. This mechanism as shown in Figs. 3 and 9 is illustrated as applied to two overlapping steel plates 62 and 63 and comprises a pair of parallel motion devices including a plurality of bars 66 each having an end pivoted to a point on a cross bar 65 attached to the sheets 62 and 63 in the relative positions shown: the opposite end of each arm 64 being pivoted to a threaded member 66. The members 66 of each device are threaded oppositely (right and left) and mounted on correspondingly threaded sections of a shaft 67 which may be operated by a handle 68 to move the members 66 of each device toward each other or apart, to decrease or increase respectively the overlap 69 of the sheets 62 and 63. The shaft 67 is retained under brackets 70 attached to sheet 63 thus permitting the sheets to move relative to
each other and to the shaft as the shaft is rotated. The arrangement shown in Figs. 8 and 9 may be used on both form bands 54 and 56 (no curvature being shown in Fig. 9 because of the large diameter and short length), since it is equally effective for expanding the band 54 against the inner top portion of the set concrete of the wall (Fig. 1) and for contracting the band 56 around the outside. Furthermore the pair of parallel motion devices, always on the face side of the concrete, keeps the sheets in perfect alignment, provides a uniform strain and overlap, and a powerful toggle action. In building a tank of any considerable size several of the devices shown in Figs. 8 and 9 are preferably used in the bands 54 and 56 and distributed around their circumference so that the form plates will not have to slide too far on the concrete during tightening.

The deck 28, like the tank, is preferably circular in shape and it is desirable that the inner form 54 be originally round and in succeeding settings be kept evenly spaced from the deck. The hose 60 is ideal for this purpose because it may be inflated with air or water (by connections not shown) to a uniform pressure so that the deck and form 54 are brought concentric with each other. Fire hose is used in this manner.

The method of application and means for hanging the hose 60 between the deck 28 and the form band 54 is shown in Fig. 6 in which a strap 80 is shown looped around the hose and provided with hooks for engaging the flange 30. It is intended that a number of such straps are to be used. The hose 60 can be employed quickly, permitting the use of a predetermined constant pressure and insures against the use of excessive or localized pressure at the top of the wall section 24.

The form band 54 may be spaced from the deck 28 and set against the top part of the wall 24 by means of jacks 82, such as shown in Fig. 7, which may be distributed around the rim of the deck and fastened to the flange 30. The jacks 82 may be used in conjunction with similar jacks on the A-frames, or the hose 60 or both. Once the tank wall is started with the form bands in proper concentric relationship and the deck also in concentric position, each succeeding setting of the forms becomes simple because the lower portion of each form will be put under stress against the upper portion of the set wall section, the outer form being preferably put under stress first.

One outstanding advantage of the floating deck is that its use in the construction operations eliminates the master of plumbing the forms or wall because the form bands are originally set with their walls in vertical position and kept that way by the deck which floats in horizontal position on the liquid in the erected portion of the tank. Even when the bands must be elevated by their mechanisms they can be brought the same distance above the deck all around or from the top of elements 50.

When water is used to counterbalance fresh concrete in the manner described above, the deck structure of Fig. 1 may be modified as shown in Fig. 5 in which the deck 71 is provided with a plurality of spaced angle brackets, one of which is illustrated, as a means for holding the lower edge of the inner form band 72 against the set concrete while the deck floats up on the rising water. The bracket comprises a vertical bar 73 which projects through an opening in the rim of the deck, a horizontal bar 74 and a web brace as illustrated, the bracket being pivoted on the rim of the deck with a slot and pin 75. Means 16 is provided for forcing the outer end of the bar 74 down, which in turn forces the lower portion of the bar 73 against a flanged roller 77 mounted on the lower edge of the form band 72. Fig. 5 shows the deck 71 near its maximum elevation for the present setting of the form band 72. The bracket may be inserted before the concrete on the deck is up sufficiently to give room for the bar 73.

When the tank wall has been carried to the desired height the deck may be used to make a reinforced concrete roof as shown in Fig. 2 in which a floating deck 94, after being stripped of all of the equipment shown in Fig. 1, is attached to the erected top of the tank wall 98 by means of a braced ring 93, and filled and covered with a concrete cover 99 as shown. The welding of the ring 88 to the deck 84 and the laying of the concrete 99 is readily and effectively accomplished by supporting the deck in position on the water in the tank. A central drain pipe 92 and a side drain pipe 94 are shown. Either may be used, depending on conditions. If the tank is to be made bomb-proof the concrete cover 99 may be somewhat heavier and made with additional reinforcing, and steel plate 96 is used elsewhere. The procedure is attached in Fig. 2, however, is preferred if the steel has no harmful effect on the liquid to be stored. The procedure of Fig. 3 gives a tank with no steel exposed.

In some cases it is desirable to have a metal lined concrete tank or container, which can be secured by modifying the procedure shown in Fig. 1 by that of Fig. 4, in which a sheet metal bottom 104 is laid on the concrete floor 106, after which the deck 108 (illustrated as floating on water) is placed as in Fig. 1, ready to start the concrete wall. In this case the lining 110, provided with spuds 111 and composed of a number of plates welded together, is set and welded in position to the edge of the bottom plate 104. With the outer and inner form bands 112 and 113 in place (illustrated in raised position and supported by the deck), the first section is poured. Water is introduced into the tank as in Fig. 1 to raise the deck during pouring or after the concrete has set, and the form bands are then raised to the next position. As additional lining sheet is required, plates 14 are also provided with spuds 111 are welded onto band 110 and to each other, the welds working directly from the deck 108. In this way a fully metal lined concrete tank or container may be made with any desired metal lining such as steel, aluminum, copper, lead, stainless steel, or brass. The metal lining is sufficiently strong to be used as an inside form the use of the inner form band 113 may be dispensed with. The use of the wall lining in this way may be aided by using the water to counterbalance the fresh concrete in the manner described above. The spuds 111 definitely anchor the lining to the concrete wall. The tank
of Fig. 4 may be covered with a metal lined roof as in Fig. 2 by welding an annular plate such as 88 to the wall lining and the deck, or by the procedure of Fig. 3 by laying the spudded lining on the planking and welding the edge to the wall lining.

While the process of the present invention is particularly described in connection with the construction of new concrete storage, the process is also adapted for the lining of old steel containers where the steel bottom and shell are badly corroded and somewhat unsafe for use. In relining a tank of this type, the old steel wall or shell is preferably used as the outside form while the deck 28 and the inside form band 54 is employed to construct a concrete wall of desired thickness inside the old steel wall after pouring the bottom. The concrete wall should be reinforced or of ample thickness because of the relatively short remaining life of the old steel wall. If desired the concrete wall constructed inside the old steel wall may be lined by utilizing the procedure and means described in connection with Fig. 4 of the drawings. If desired the concrete wall may be placed outside the old steel wall which then becomes the inner form. In this case the outer form band may be raised by any suitable means. A cement cover for new steel tanks may be applied by substantially the procedure outlined in connection with Fig. 4, in which the steel and concrete walls may be constructed at the same time. This type of structure is applicable to large underground storage where the concrete covering prevents collapsing of the steel shell and stops soil corrosion.

In constructing walls of concrete as described in connection with Fig. 1 is may be desirable to reduce the thickness of the wall toward the top of the tank since less thickness will be required to withstand the hydrostatic head of liquid. This may be accomplished by removing a section of sheet from the outer form band and set the band in on a smaller circumference as indicated in Fig. 10.

Where relatively large tanks are to be roofed or tanks are to be underground and covered over to provide bomb-proof conditions, it is usually desirable to provide one or more coners in the tank to support the roof. The procedure of Fig. 1 may be augmented by that shown in Fig. 11 to provide any number of concrete columns which are erected along with the wall. In this figure the deck 115 is provided with an opening within an annular flange 116, in which a column 118 is to be constructed by the use of a cylindrical form 120. The form is supported on the edge of the flange 116 by means of notched positioning brackets 122, when the pouring is done with the deck in fixed position. When the form 120 is to be raised the deck will be split lengthwise and provided with take-up lugs and bolts. If the column is to be covered with sheet metal the form need not be split, but successive sections may be welded together and merely kept in a concentric position in the flange 116.

Fig. 12 illustrates a procedure for tying the top of a column to the deck in a case such as in Fig. 2, and to the concrete roof. In this figure a column 124 has been completed with steel reinforcing rods 126 projecting above to be imbedded into a concrete roof. The deck 128, held up by water and provided with an annular flange 130 around the column is secured thereto by welding a flat annular plate 132 to the inside of the flange 130 while the plate rests on the top of the concrete column.

In completing a tank such as shown in Fig. 1, it is common to provide a swing line for withdrawing oil from and supplying oil to the tank. Such a swing line may be attached inside the tank to the line 134 in the usual way.

Additional equipment not shown can be carried onto the deck arrangement illustrated in Fig. 1, such as necessary tools and various materials as may be desired. It is apparent that a deck of the type illustrated and described is capable of carrying enormous loads because of its great displacement of water. This may be illustrated by noting the displacement necessary to carry the two form bands for a concrete tank 100 feet in diameter. Assuming the bands to be of 1/8 inch steel and 5 ft. high, it is calculated that, with a deck area somewhat smaller than the inside diameter of the tank only 0.6 of an inch of water would be displaced by the weight of the form bands.

The process of the present invention may be conveniently applied in the construction of bomb-proof tanks for, for example, by excavating a relatively long channel sufficient to accommodate a number of tanks, constructing the tanks in the manner described above and filling around them with previously excavated earth and covering them over to any desired depth. In case a tank is to be constructed in a rock formation, the excavation for the tank may be made with reasonable accuracy in the rock structure and the tank constructed by the use only of the inner form band, the rock walls being used for the outer form. It is apparent that underground tanks of this type greatly reduce the fire hazard and should correspondingly reduce insurance costs. Furthermore, completely covered tanks are not subject to sudden atmospheric temperature changes and are therefore ideal for storing volatile oils such as gasoline. Such concrete tanks are capable of withstanding substantial internal vapor pressures. Even when constructed above ground concrete storage tanks are much less affected by atmospheric temperature changes than are steel tanks of like capacity.

Where concrete storage is constructed in accordance with the process of the present invention, the floating deck may be effectively used while the water is being withdrawn, as a working platform for cleaning down the inside wall or for applying a smooth plaster coat to the inside wall, or both. In many cases, it will be desirable to apply a special coating which will be highly resistant to the particular fluid to be stored. Where a concrete roof is applied in accordance with the procedure shown in Fig. 3 of the drawings, a considerable opening such as a manhole may be left in the roof so that the above-mentioned cleaning and coating operations may be carried out after the floating deck has been lowered sufficiently to permit entrance and give room for such operations. Instead of using the floating deck as a permanent roof, such deck may be equipped with a marginal seal and employed in the usual way as a floating roof to prevent evaporation losses. From the foregoing description of the improved method of constructing storage tanks for liquids, it will be apparent that the method will greatly reduce the cost of construction as well as the time usually required for constructing a tank, because the use of the floating deck or platform provides ample work space, avoids the
use of inside and outside scaffolding and the necessity for bracing. The floating deck furthermore stays in a substantially horizontal position at all times, so that the walls are always vertical.

The improved method of the present invention results in a considerable saving because the tank is automatically and continuously tested for defects and leakage as the erection proceeds. Furthermore, the presence of liquid in the tank shell converts the floating deck into a level so that plumbing of the walls or forms is entirely unnecessary.

While in the preferred form of the invention the floating deck and the equipment thereon is preferably employed in handling the form bands, certain of the advantages may be obtained by using other means for raising the form bands. For example, a ring of gin-poles may be set up around the form bands just outside the tank foundation, and used for elevating the form bands. Where the tank or receptacle is to be constructed in a pit or excavation, the gin-poles may be set up inside the form bands, but where possible it is desirable to provide means for introducing water into the constructed portion of the tank to counter-balance the wet concrete, and also to provide a circular inner form support such as the deck for setting or supporting the inner form band. Such a support may be elevated by the gin-poles.

While the present invention has been described more particularly in connection with the building of tanks for liquids, such as petroleum oils, it is to be understood that the improved process of the present invention may be employed in the construction of any type of receptacle which may be built from concrete, and it is to be further understood that the improved method may be employed merely in the construction of the shell or wall of any such receptacle, such as for water, dry holders and other structures which include an annular shell in vertical position. In the construction of gas holders the use of water inside the shell during the construction may be restricted to the lower portion of the shell where the wall will be of sufficient strength to withstand the hydrostatic head of water, for example, the first thirty feet. Higher portions of the shell may be constructed by a modified procedure in which tubular metal scaffolding may be provided on the floating deck. In this procedure the floating deck may be lowered after the first stage of construction to install the scaffolding for another thirty or forty foot section of the shell. Various other modifications may be made in the improved process of the present invention to adapt it for use in the construction of various types of receptacles having vertical shells equivalent to that of the tank shell specifically described herein.

The method of the present invention is preferably applied to the construction of cylindrical shells or walls, but may be used in the construction of annular substantially vertical walls of other convex closed curved shapes, such as for example as oval or elliptical. Furthermore, the form bands may be made of material other than sheet steel, as for example, plywood sheets provided with spaced steel retaining strips or bands.

Some of the advantages and improvements of the herein claimed method for constructing concrete storage are as follows:

1. Reduction of the hazard to workmen.
2. Allows an increased number of men to work on a tank and with much greater comfort.
3. Eliminates the fire hazard from wooden scaffolding.
4. Permits large quantities of materials to be carried along with the erection crew for convenient use.
5. Permits the painting of the outside of the tank or the filling in around the tank wall as the construction proceeds.
6. Avoids the cost of and hauling of scaffolding for field erection of oil storage and other tanks.
7. Some of the advantages of concrete underground storage constructed in accordance with the present invention are as follows:
   1. Relatively long life compared to the life of steel tanks placed underground.
   2. High resistance to external pressure when empty.
   3. Saves space and permits the use of the ground surface above the tank for a wide variety of purposes.
   4. Greatly reduces the fire hazard and cost of insurance.
   5. Reduces vapor pressures, because cooler, and practically eliminates breathing losses common in the storage of crude oils and gasoline in ordinary tankage.
   6. Eliminates the danger from lightning.

From the foregoing description it will be apparent to those skilled in the art that various modifications and alternations may be made in the procedure and in the equipment employed without departing from the spirit and scope of the invention as defined by the appended claims.
ing the wall of the tank, which comprises setting the bands in the desired position for the tank wall on a previously prepared foundation for the tank wall, providing a floating roof of only slightly smaller diameter than the inside diameter of the tank within the tank area to which said bands are attached, pouring a course of concrete of the wall in the form and permitting it to set, releasing the bands from the set concrete course, raising each band as a unit to the desired height for the next course while permitting each band to overlap on the set course of concrete, said bands and said floating roof being raised by introducing a liquid into the constructed portion of the tank to float said roof and thereby raise the bands to said desired height, expanding the overlapped portion of the inner band and contracting the overlapped portion of the outer band against the intervening portion of the set concrete course, and pouring the next course of concrete for the wall.

4. The method of constructing a concrete vertical cylindrical shell of a floating roof storage receptacle for holding fluids, which comprises the steps of providing two concentric form bands of substantial width and of large diameter on edge and in concentric spaced relation to each other on a bottom foundation for the receptacle, providing a floatable roof of substantial displacement within the area to be surrounded by the shell, said roof being of only slightly smaller diameter than that of the inner form band and being provided with means thereon for elevating said bands, pouring a fluid concrete mix into the annular space provided between the two form bands until a concrete ring of substantially uniform height is secured, allowing the poured concrete ring to set in said form bands, expanding the outer band and contracting the inner band to release them from the set concrete ring, introducing a liquid into the constructed portion of the receptacle to elevate the roof, elevating each band as a unit to a higher level by the use of said means on said roof so that their lower edges overlap the upper portion of the set concrete ring, contracting the outer band and expanding the inner band against the upper portion of the set concrete ring, pouring fluid concrete mix into the annular space between the elevated bands in their new positions to form a new concrete ring, permitting the new concrete ring to set, and repeating the operations until a cylindrical shell of desired height is obtained.

5. The method of constructing a concrete vertical cylindrical shell of a receptacle for holding fluids, which comprises the steps of providing two concentric form bands of substantial width and of large diameter on edge and in concentric spaced relation to each other on a bottom foundation for the receptacle, providing a floatable roof of substantially smaller diameter than that of the inner form band within the area to be surrounded by the shell, pouring a fluid concrete mix into the annular space provided between the two form bands until a concrete ring of substantially uniform height is secured, allowing the poured concrete ring to set in said form bands, expanding the outer band and contracting the inner band to release them from the set concrete ring, introducing a liquid into the constructed portion of the receptacle to elevate the roof, elevating each band as a unit to a higher level so that their lower edges overlap the upper portion of the set concrete ring, contracting the outer band and expanding the inner band against the upper portion of the set concrete ring, pouring fluid concrete mix into the annular space between the elevated bands in their new positions to form a new concrete ring, permitting the new concrete ring to set, and repeating the operations until a cylindrical shell of desired height is obtained.

7. The method of constructing a receptacle for holding fluids including a vertical cylindrical concrete shell and a floatable roof adapted to be supported on the stored fluid and to protect the same, which comprises the steps of providing a floatable roof within the area to be surrounded by the cylindrical shell, said roof being only slightly smaller in diameter than the inside diameter for the shell, constructing the lower portion of said shell of concrete around said floatable roof by the use of a form for concrete mix, introducing water into said constructed lower portion of said shell to float said roof inside the form and elevate it to a height suitable to work from in the construction of a higher portion of said shell, constructing succeeding portions of said shell by raising said form containing concrete mix thereinto, and using said floatable roof to elevate said form and to work from in the construction of said succeeding portions of said shell.

8. The method of constructing a floating roof tank for storing oils and other liquids including a vertical cylindrical concrete shell and a buoyant roof adapted to be supported on the stored liquid and constructed so as to protect the liquid, which comprises the steps of providing a buoyant floatable roof within the area to be surrounded by the cylindrical shell, said roof being only slightly smaller in diameter than the inside diameter for the shell, constructing the lower portion of
said shell of concrete around said floatable roof by the use of a form for concrete mix, introducing water into said constructed lower portion of said shell to float said roof and elevate it to a height suitable to work from in the construction of a higher portion of said shell, constructing succeeding portions of said shell by raising said form and by pouring concrete mix thereinto, and using said floated roof to work from in the construction of said succeeding portions of said shell.

9. The method as defined by claim 8 in which at least a portion of the weight of the fluid concrete mix in the form is counterbalanced by providing a head of water within the shell and within the form to a sufficient height to effect said counterbalance.

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