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3,389,559 6/1968 Logan 114/0.5 T X

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[54] **SUBMERGED OFFSHORE FLUID STORAGE FACILITY**
9 Claims, 9 Drawing Figs.

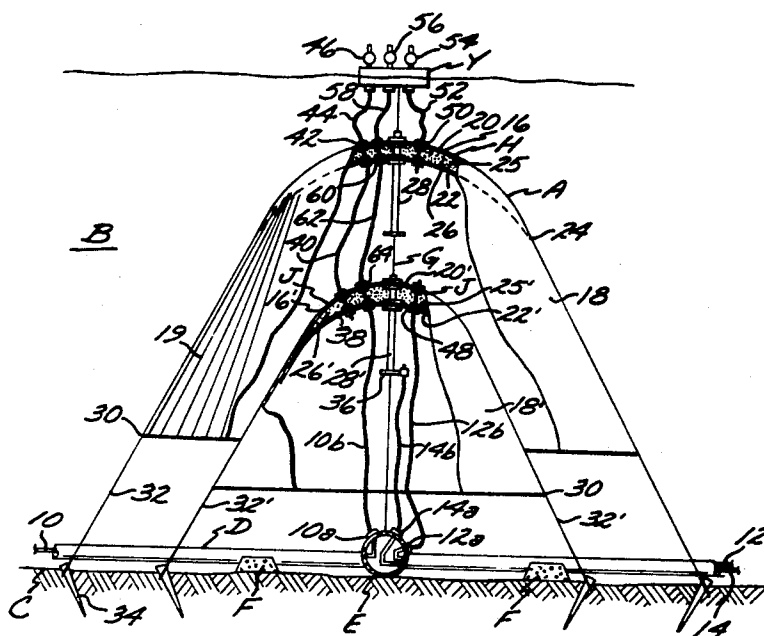
[52] U.S. Cl. **114/0.5, 61/1**
[51] Int. Cl. **B63b 35/00**
[50] Field of Search **61/1; 114/0.5 T, 0.5, 74**

[56] **References Cited**

UNITED STATES PATENTS

3,339,512 9/1967 Siegel 114/0.5 T

ABSTRACT: A prefabricated offshore fluid storage facility for one or more fluids that may be moved in a collapsed condition to a desired location on a body of water, and then expanded and anchored beneath the surface of the water to store one or more fluids therein, the specific gravities of which are less than that of the water in which the facility is submerged. The facility of the present invention may also be used to protect submerged storage tanks. Also, if the facility is anchored above fissures, cracks or portions of faults in a submerged land area, it will capture and retain hydrocarbon products escaping therefrom.



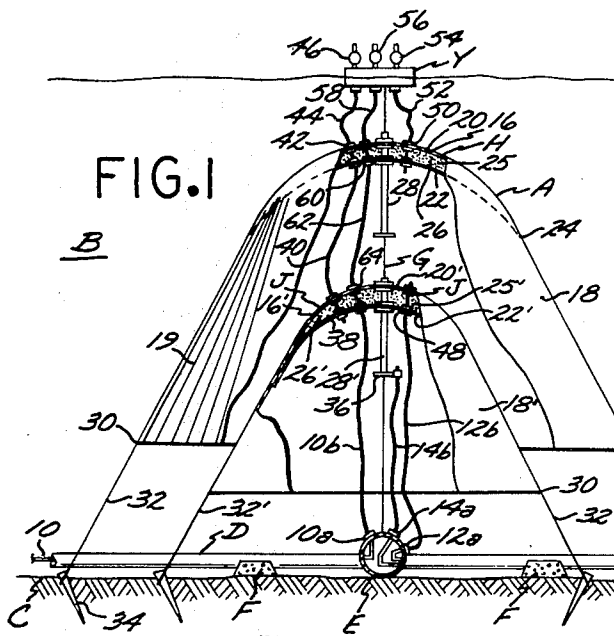


FIG. 1

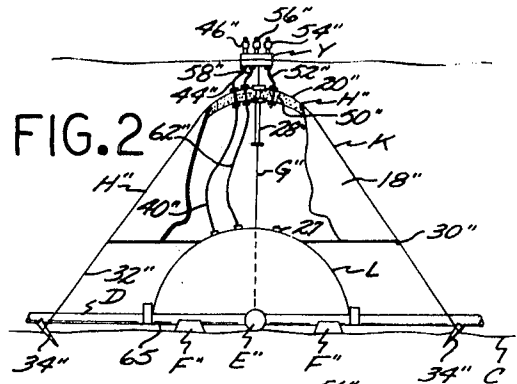


FIG. 2

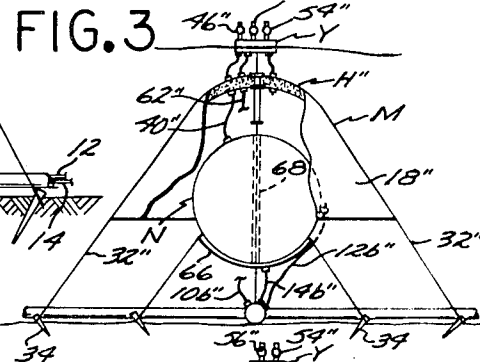


FIG. 3

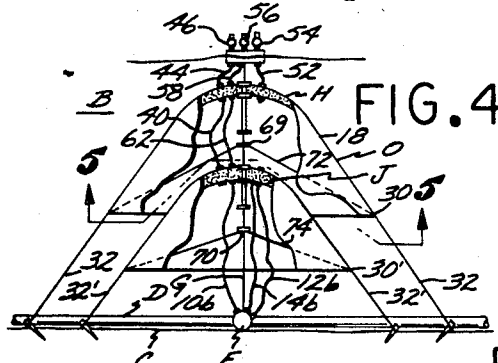
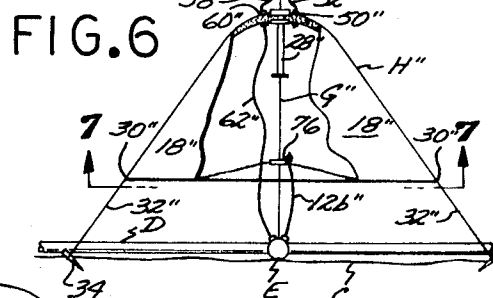


FIG. 4



SUBMERGED OFFSHORE FLUID STORAGE FACILITY

BACKGROUND OF THE INVENTION

1. Field of the Invention

That of submerged offshore storage facilities adapted to contain one or more fluids, the specific gravities of which are less than that of the water in which the facility of the present facility is submerged, with this facility being capable of protecting submerged liquid storage tanks, and safeguarding against the escape and subsequent wide distribution of hydrocarbon products rising from underwater faults.

2. Description of the Prior Art

The present invention comprises a collapsible, nonrigid, submerged, offshore fluid storage facility, and is an improvement over my invention disclosed and claimed in U.S. Pat. No. 3,339,512 entitled "Multiple Storage and Redistribution Facility" that issued on Sept. 5, 1967. The storage facility disclosed in my prior patent is undefined as to being a rigid or collapsible structure and one operational disadvantage thereof is that it is difficult to move to a new site. This installation disadvantage of my prior invention is also found in other prior art devices of this nature that are of rigid construction.

Inflatable liquid storage facilities have been proposed and used to a limited extent in the past for underwater containment of fluids. The operational disadvantages of such inflatable facilities is that they have found to be limited as to size, are difficult to fabricate, assemble, and install, are not adaptable to a variety of user operations, and impose high stresses on the mooring means associated therewith when the facilities are subjected to strong turbulent currents and storm fluid buoyancy forces.

Such inflatable facilities or those of semirigid structure are designed for location near the surface of the body of water in which they are submerged, and as a result are subjected to heavy currents, wind, and wave action, and ice in cold climates.

The present invention is a nonrigid, submergible, prefabricated, fluid storage facility that may be moved from one site to another without difficulty, and one which substantially eliminates the operational disadvantages of prior devices of the type described. In addition, the present invention is more versatile in use than previously available storage means; in fact, the present invention may be used to protect underwater bottom-located rigid and nonrigid storage tanks, as well as serve as a safeguard to prevent escape and subsequent wide distribution of hydrocarbon products arising from underwater faults, fissures and cracks.

SUMMARY OF THE INVENTION

A prefabricated underwater storage facility that may be moved in a collapsed condition to a desired location to subsequently store one or more different fluids having specific gravities less than that of the water in which the facility is submerged. The present facility may also be used to protect underwater storage tanks, and act as a safeguard to prevent the escape and subsequent wide distribution of oil and tar stemming from underwater faults.

A major object of the present invention is to provide a prefabricated, nonrigid underwater storage facility for one or more fluids, the specific gravities of which are less than that of the water in which the facility is submerged, which facility is capable of being moved to a desired location in a collapsed condition, and thereafter expanded and anchored in a fluid-containing position.

Another object of the invention is to supply an underwater storage facility that may be used to protect a submerged liquid storage tank, and also act as a safeguard to prevent the escape and subsequent wide distribution of hydrocarbon products seeping from an underwater fault.

A still further object of the invention is to furnish an underwater fluid storage facility, which because of its shape and the depth at which it may be anchored, imposes no excessive

stresses on the mooring means associated therewith, due primarily to the fact that the facility has a low drag coefficient and is beneath the strong turbulent surface currents and wind and wave action.

A still further object of the invention is to provide an underwater fluid storage facility that is not a navigational hazard, and one which is provided with a secondary anchoring means for stability, with the second anchoring means being sufficiently strong to prevent overturning of the surfacing facility resulting in loss of the fluid contents thereof in the event the first anchoring means is destroyed by a typhoon, earthquake, or the like.

Yet another object of the invention is to provide an underwater fluid storage facility that includes means for minimizing the intermixing of the fluids contained therein with the water in which the facility is submerged.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a combined side elevational and vertical cross-sectional view of a first form of prefabricated, collapsible, submerged, storage facility that is adapted to store two separate fluids out of contact with one another or to utilize the outer structure as a protective barrier for the original invention;

FIG. 2 is a combined side elevational and vertical cross-sectional view of a second form of underwater fluid storage facility that serves not only that function, but also acts as a protector for a bottom-located rigid or semirigid underwater fluid storage tank;

FIG. 3 is a combined side elevational and vertical cross-sectional view of a third underwater fluid storage facility that serves not only that function, but also acts as a protector for an underwater rigid or semirigid fluid storage tank located off the bottom;

FIG. 4 is a combined side elevational and horizontal cross-sectional view of a fourth form of underwater fluid storage facility, which is provided with dual anchoring means for stability, with dual anchoring means only becoming effective after failure of the first anchoring means;

FIG. 5 is a transverse cross-sectional view of the fourth form of the device, taken on the line 5—5 of FIG. 4;

FIG. 6 is a combined side elevational and horizontal cross-sectional view of a fifth form of underwater fluid storage facility which includes meshlike or porous sheet means for preventing or minimizing the intermixing of the stored fluid with the water in which the device is submerged;

FIG. 7 is a horizontal cross-sectional view of the fifth form of the device, taken on the line 7—7 thereof;

FIG. 8 is a combined side elevational and vertical cross-sectional view illustrating the manner by which any one of the first to fifth forms of the invention may be used as a support for a tubular chute through which fluid concrete is discharged from a boat or barge to the bottom of the body of water to define an anchor block or to stabilize the bottom material in the immediate vicinity of a weakened anchor; and

FIG. 9 is the same view as shown in FIG. 8, but looking end-on to the boat or barge.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The first form A of the device shown in FIG. 1 is submerged in a body of water B above the floor C thereof. The first form A of the device is preferably submerged in the body of water B a sufficient depth that it is not appreciably affected by strong turbulent surface currents or wind or wave action.

In the first form A of the storage facility, the fluids which to be stored are delivered thereto through three pipelines 10, 12 and 14 that are encased in a cylindrical semirigid, water-filled (fresh) shell D which extends outwardly from opposite sides of a hollow sphere E. The shell D is supported on a succession of horizontally spaced, concrete supports F that rest on the floor C. Each of the pipelines 10, 12 and 14 is connected through incorporated valves to tubular fittings 10a, 12a and 14a, respectively, on the sphere E, which fittings are in turn con-

nected to flexible hoses 10b, 12b and 14b, respectively. The shell D is defined by a number of tubular sections (not shown) that are connected end to end. The shell D serves to protect the pipelines 10, 12 and 14 from physical contact with objects that might damage the same, as well as protect the pipelines from marine growth.

A first taut cable G extends upwardly from the sphere E and is connected by conventional means to a buoy Y that floats on the surface of the body of water B. A first fluid-containing assembly H is provided, that includes a rigid, foam-filled, upwardly convex buoyant cap 16 from which vertically pleated fabric 18 depends. The fabric 18 in frustoconical in shape when in a fluid-containing position, as may be seen in FIG. 1. Fabric 18 is preferably formed from woven or fused, nylon cord or glass fibers, or the like, that is substantially impervious to the fluid to be stored within the confines thereof. Pleats 19 in the pliable fabric are shown in FIG. 1.

First cap 16 (FIG. 1) is defined by two upwardly convex sheets 20 and 22 of different radii of curvature, which are bonded together on the peripheries 24 thereof by welding, or the like. The sheets 20 and 22 cooperatively define a confined space 25 that is filled with a buoyant material 26. An elongate tubular guide 28 extends through the plates 20 and 22 to slidably and sealingly engage the cable G. The lower peripheral edge 30 of the fabric 18 has a number of anchor cables 32 extending downwardly therefrom to anchors 34 that are driven into the floor C.

A second fluid-containing assembly J is provided that is of the same structure as the first assembly H, but is smaller in size, as shown in FIG. 1. Components of the second assembly J are identified in FIG. 1 by the same numerals used for that purpose in the first assembly H, but to which primes have been added. Second assembly J is situated below first assembly H, in vertical spaced relationship. The lower edge 30' of fabric 18' is connected by cables 32' to anchors 34.

Fluid flowing in the pipeline 14 may be discharged into the second fluid assembly J through the hose 14b, the upper end of which hose is supported by a bracket 36 from the second guide 28'. A tubular fitting 38 extends through second cap 26 and is connected to a hose 40. The hose 40 is connected to a second tubular fitting 42 that extends through first cap 16. A flexible hose 44 extends upwardly from fitting 42 to a valved outlet 46 supported on buoy Y. By opening the outlet 46, fluid in the second fluid-containing assembly J may be pumped into a ship (not shown) positioned adjacent to the buoy Y.

Fluid flowing in pipeline 12 may be discharged into the first fluid-containing assembly H. A tubular fitting 48 extends through second cap 16', which fitting is connected to hose 12b. Hose 12b is connected to fitting 12a. The upper end of fitting 48 is in communication with the interior of the fluid-containing assembly H. Stored fluid which has accumulated in assembly H may be drawn therefrom through a tubular fitting 50 that extends through first cap 16. Fitting 50 is connected by a hose 52 to a valved outlet 54 supported on buoy Y.

A valved outlet 56 is provided on buoy Y that is connected by a hose 58 to a tubular fitting 60 that extends through first cap 16, and this fitting is connected to a second hose 62 that is in communication with a tubular fitting 64. Fitting 64 extends through second cap 16' and is connected to hose 10b, which hose is connected to fitting 12a. By opening valve outlet 56, a ship (not shown) may withdraw fluid from pipeline 10, without this fluid first being stored in either the first fluid-containing assembly H or the second assembly J.

In use, operation of the first form A of the storage facility is most simple. The pipelines 10, 12 and 14, the protective shell D, and sphere E are first placed in position on the floor C. The first form A of the invention is moved in a collapsed condition to a position above the sphere E where the buoy Y is then anchored to the sphere by conventional means.

Anchors 34 are then forced into the floor C in circumferentially spaced positions around the sphere E. Anchor cables 32 and 32' are thereafter connected to the anchors 34, which cables in conjunction with the buoyant caps 16 and 16',

serve to hold the first and second fluid-containing assemblies H and J in the configuration shown in FIG. 1. Fluid may then be discharged into the first fluid-containing assembly H for storage through the hose 12b. Fluid may also be discharged into the second fluid-containing assembly J through the hose 14b. The means for removing the stored fluids from first and second assemblies H and J has already been described in detail and need not be repeated.

The second form K of the invention illustrated in FIG. 2 is similar to the first from A, but the second fluid-containing assembly J is replaced by a second fluid-containing assembly L. Elements comprising the second form K which are common to the first form A are identified in the drawing by the same numerals, but to which double primes have been added. Second fluid-containing assembly L is an inverted hemispherical shell, the lower edges 65 of which supported from the shell D'' and supports F''. The second fluid-containing assembly L serves the same function as the second fluid-containing assembly J in the first form A. Second form K of the invention operates in substantially the same manner and produces the same results as the first form A. Fluid is discharged into the first fluid-containing assembly H'' through a tubular fitting 27 supported on the second fluid-containing assembly L or left filled with sea water assembly H'' serves as a protective secondary container for assembly L.

The third form M of the invention illustrated in FIG. 3 is similar to the first form A, but in which the second fluid-containing assembly J is replaced by an enclosed spherical tank N. The rigid elements 66 of tank N are secured to the lower exterior part thereof, which elements are connected to anchor cables 32'' that extend to stakes 34. Tank N must be of such weight as to be buoyant in the body of water B when filled with a liquid of the highest specific gravity to be stored therein. Cable G'' extends upwardly through a diametrically disposed tubular guide 68 in the tank N, as well as an opening (not shown) in the elements 66. Fluid is transferred from the hoses 10b'', 12b'' and 14'' to the valved outlets 46'', 54'' and 56'' in the same manner described in detail in conjunction with the first form A of the storage facility. The first fluid-containing assembly H'' not only serves to store fluids, but acts as protection for the tank N.

The fourth form O of the invention, shown in FIG. 4, is of the same structure as the first form A thereof, but includes additional elements. Elements comprising the fourth form O of the invention common to those of the first form A are identified in FIG. 4 by the same numerals. Upper and lower rings 69 and 70 are secured in vertically spaced relationship on cable G (FIG. 4). A number of slightly slack, circumferentially spaced cables 72 extend radially from upper ring 69 to the peripheral lower edge 30 of the fabric 18. Likewise, a number of slightly slack, circumferentially spaced cables 74 extend radially from lower ring 70 to the lower peripheral edge 30' of the fabric 18'.

In the event that the fourth form O of the invention is subjected to an extremely violent act of nature such as a typhoon, and the anchor cables 32 and 32' are broken, the cables 72 and 74, together with cable G will allow the first and second fluid-containing assemblies H and J to move towards the surface of the body of water B. The cables 72 and 74, and cable G will maintain the first and second fluid-containing assemblies H and J in upright positions when they so rise, and prevent them from assuming horizontal positions where stored fluids can spill therefrom. FIG. 5 illustrates the positions of the cables 72 that radiate from the ring 69 to the peripheral edge 30 of sheet 18.

The fifth form P of the invention shown in FIG. 6 is of the same structure as the second form K, but the second fluid-containing assembly is omitted therefrom. Those elements of form P of the facility common to the second form K thereof are identified (FIGS. 6 and 7) by the same numerals. In the fifth form P, a ring 76 is secured in a fixed position to the cable G'' that has a slightly slack net or meshlike fabric 78 extending therefrom to the peripheral edge 30'' of fabric 18''. The net

76 prevents any substantial intermixing of fluid in fluid-containing assembly H'' with the body of water B.

FIGS. 8 and 9 illustrate the manner by which the fluid-containing assembly H'' of form P, or the counterpart H thereof illustrated in FIG. 1, may be used to support a chute 80 through which fluid concrete may be discharged downwardly from a boat 82 positioned alongside buoy Y. As the concrete discharges from the lower end of chute 80 it may be directed around the anchors 34 to define individual anchor blocks 84 or stabilize the immediately surrounding terrain.

I claim:

1. A storage facility for a first fluid substantially immiscible with water that may be moved in a collapsed condition to a desired site on a body of water and then submerged and expanded to a fluid-containing configuration, including:

- a. a buoy;
- b. a first cable depending from said buoy;
- c. first means for anchoring the lower end of said cable in a taut condition to the bottom of said body of water;
- d. a first rigid buoyant cap slidably and sealingly mounted on said first cable;
- e. a first continuous sheet of pliable material that extends downwardly from said first cap and is sealed thereto, which sheet is substantially impervious to said fluid and of such configuration as to be expanded into a frustoconical shape and open at the bottom thereof;
- f. a plurality of second cables extending down in circumferentially spaced relationship from a lower edge of said sheet;
- g. second means for anchoring the lower ends of said second cables to said bottom, with said second cables being of such length as to hold said first cap below the surface of said body of water, which first cap and second cables cooperatively hold said sheet material in said frustoconical shape whereby fluid of lower specific gravity may be discharged upwardly through the lower open end of said frustoconical sheet material to storage thereof within the confines thereof;
- h. third means for discharging fluid into said confines;
- i. fourth means for removing fluid stored in said confines;
- j. a continuous sheet of woven material that extends inwardly from a lower circumferential edge of said sheet of pliable material to said first cable to minimize the mixing of fluid stored in said confines with the water of said body of water; and
- k. fifth means for supporting an inner portion of said sheet of woven material from said first cable at a fixed position thereon intermediate said first buoyant cap and said first means for anchoring said first cable.

2. A storage facility for a first fluid substantially immiscible with water that may be moved in a collapsed condition to a desired site on a body of water and then submerged and expanded to a fluid-containing configuration, including:

- a. a buoy;
- b. a first cable depending from said buoy;
- c. first means for anchoring the lower end of said cable in a taut condition to the bottom of said body of water;
- d. a first rigid buoyant cap slidably and sealingly mounted on said first cable;
- e. a first continuous sheet of pliable material that extends downwardly from said first cap and is sealed thereto, which sheet is substantially impervious to said fluid and of such configuration as to be expanded into a frustoconical shape and open at the bottom thereof;
- f. a plurality of second cables extending down in circumferentially spaced relationship from a lower edge of said sheet;
- g. second means for anchoring the lower ends of said second cables to said bottom, with said second cables being of such length as to hold said first cap below the surface of said body of water, which first cap and second cables cooperatively hold said sheet material in said frustoconical shape whereby fluid of lower specific gravity may be

discharged upwardly through the lower open end of said frustoconical sheet material to storage thereof within the confines thereof;

- h. third means for removing fluid stored in said confines;
- i. a ring secured to said first cable at a fixed position thereon intermediate said first buoyant cap and first means for anchoring said first cable; and

a plurality of circumferentially spaced third cables extending radially from said ring to a lower edge of said sheet of pliable material, which third cables allow said first buoyant cap and said pliable sheet material to rise in said body of water but not overturn to spill said fluid from said confines of said second cables should they be broken by extraordinary stresses placed thereon.

3. A storage facility as defined in claim 3 which further includes;

k. fourth means for storing a second fluid below the surface of said body of water and below said sheet of said pliable material when said sheet is in said frustoconical shape for purposes of protection;

l. fifth means for discharging said second fluid into said fourth means; and

m. sixth means for removing said second fluid from said fourth means.

4. A storage facility as defined in claim 3 wherein said fourth means comprises an inverted hemispherical shell occupying a fixed position relative to the bottom of said body of water.

5. A storage facility as defined in claim 3 wherein said fourth means comprises:

n. a spherical buoyant tank through which a tubular guide diametrically extends, with said guide slidably engaging said first cable;

o. a plurality of circumferentially spaced third cables secured to the lower portion of said tank and depending therefrom; and

p. seventh means for anchoring lower ends of said third cables to the bottom of said body of water, which cables are of such length that said tank floats in said body of water at least partially below said sheet of pliable material when said sheet is in said frustoconical shape.

6. A storage facility as defined in claim 3 wherein said fourth means comprises:

n. a second buoyant cap slidably and sealingly mounted on said first cable a substantial distance below said first cap;

o. a second continuous sheet of pliable material that extends downwardly from said second cap and is sealed thereto, which sheet is substantially impervious to said second fluid and is of such shape as to be expandable into a frustoconical shape, open at the bottom thereof;

p. a plurality of third circumferentially spaced cables depending from a lower edge of said second sheet and inwardly to a center ring slidably mounted to the said first cable; and

q. seventh means for anchoring lower ends of said third cables to the bottom of said body of water.

7. A storage facility as defined in claim 2 wherein said first sheet of pliable material has pleats formed therein to permit collapse thereof into a compact configuration.

8. A storage facility as defined in claim 6 wherein said second sheet of pliable material has pleats formed therein to permit collapse of said second sheet into a compact configuration.

9. A storage facility as defined in claim 2 which further includes;

j. a source of fluid concrete above the surface of said body of water and adjacent said buoy; and

k. a tubular chute supported at a downwardly inclined angle on the exterior surface of said first sheet material when the same is of said frustoconical shape, with said chute being capable of receiving said fluid concrete discharged downwardly therethrough to at least partially define said second means.