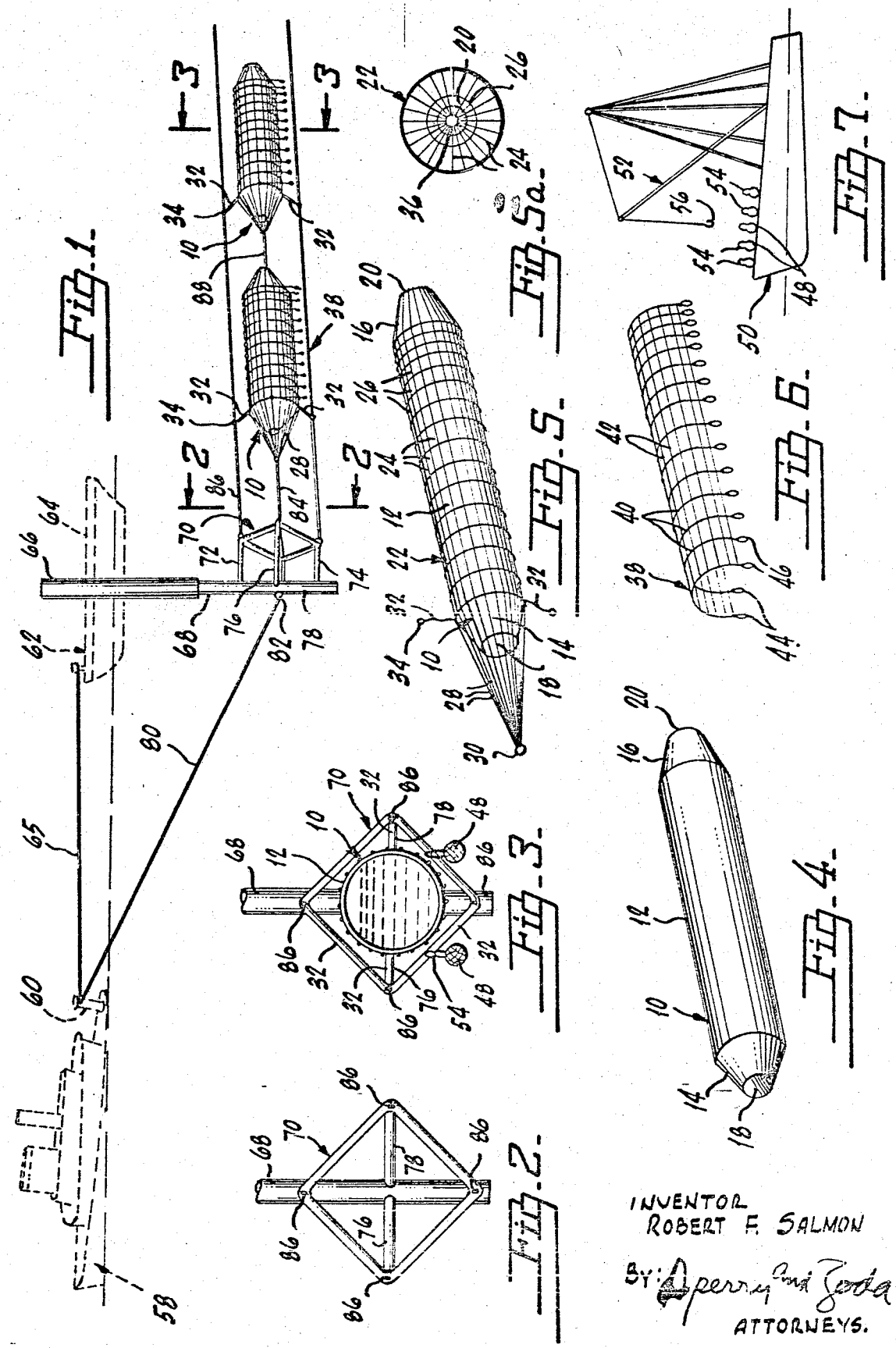
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MARINE TRANSPORT APPARATUS AND METHOD

Filed Aug. 14, 1968 2 Sheets-Sheet 1



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MARINE TRANSPORT APPARATUS AND METHOD

Filed Aug. 14, 1968 2 Sheets-Sheet 2

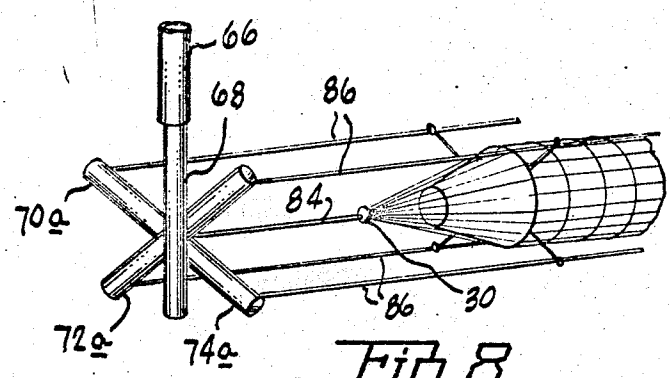


Fig. 8.

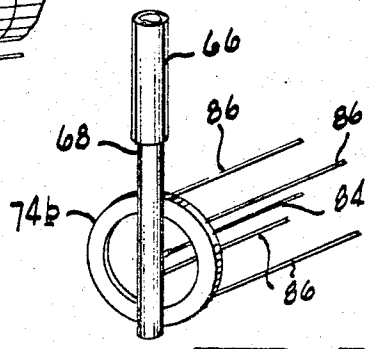


Fig. 9.

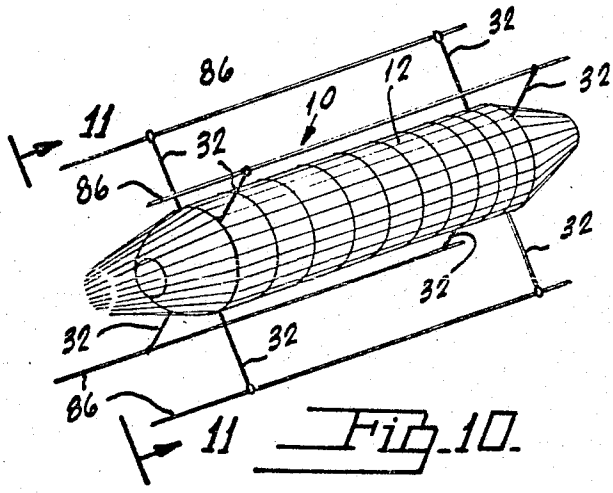


Fig. 10.

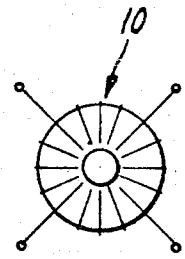


Fig. 11.

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MARINE TRANSPORT APPARATUS AND METHOD

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Int. Cl. B63b *21/00, 25/08*
U.S. Cl. 114—235 8 Claims

ABSTRACT OF THE DISCLOSURE

A marine transport system involving a non-rigid container with a surrounding net associated with a tow bar from a tug vehicle. The container is employed by the initial incorporation of a gaseous medium (such as air) therein which is displaced by liquid to a selected buoyancy relationship between the container and its contents and the float media. Thereafter, the remaining gas is evacuated to submerge the container to a towing depth below the level of wave action. The liquid can be the material transported. Or, the containers may serve as suspension means for solid materials carried in ballast bags depending from a container-straddling saddle. In another use, both the liquid within the container and the solids within the bags may constitute the materials to be transported.

BACKGROUND OF THE INVENTION

Field of the invention

This invention pertains to a system of water transport, and to apparatus employed in such system.

Description of the prior art

Various means have heretofore been proposed for the supplying of fresh water to geographic areas lacking in a natural supply thereof or, which through poor water management, are otherwise hindered by an insufficient fresh water supply. Many current efforts in the direction of fresh water supply have been directed to desalinization of sea water, or to complex river diversion or pumping operations. These prior proposals, while generally effective, involve cost factors which, in practice, render them uneconomic for many potential users, particularly in developing areas.

Transportation of fluids by water borne carriers of various types has also been the subject of previous discussion in patents and elsewhere. Examples of U.S. patents in this field are as follows: 2,391,926, Scott, Jan. 1, 1946; 2,979,008, Whipple, Apr. 11, 1961; 3,001,501, Hawthorne, Sept. 26, 1961; 3,018,748, Denis, Jan. 30, 1962; 3,056,373, Hawthorne, Oct. 2, 1962; 3,067,712, Doerpinghaus, Dec. 11, 1962; 3,085,533, Goryl, Apr. 16, 1963; 3,334,676, Girard, Aug. 8, 1967.

SUMMARY OF THE INVENTION

The present invention relates to a method and apparatus for the transportation of large volumes of fluid, and more specifically, to the movement of very substantial quantities of fresh water by sea. This method and apparatus is directed essentially to the alleviation of water shortages occurring in arid and/or overpopulated areas by economical transport of the fresh water from water-rich areas to areas of need.

This invention comprehends the transport of fresh water by marine conveyances in the form of large, non-rigid containers towed either singly or in series by a tug vehicle. In a typical example, the invention would permit the transfer of 600 million gallons of fresh water a distance of 1,500 miles at a speed of 2.6 knots. This would involve approximately 22 days of travel time, but would,

in the case of a community or industry having a 10 million gallon per day consumption requirement, represent a 60-day water supply. Thus, by multiplying the load capacity of the system, any consumption factor can reasonably be met.

An objective of the invention therefore, resides in the provision of a fluid transport system of low cost per unit volume of fluid transported in comparison to other systems.

Fluid transfer by towed marine containerization has, as indicated above, previously been proposed as a solution to fluid transportation problems. These previous proposals have proven inadequate for the transportation of large volumes of fresh water, as for example, where the containers are to be supplied in lengths of 1,000 feet and diameters of 100 feet, which is the general size range here contemplated, due principally to structural failure of the containers when made in this size range, or because of the cost of manufacture and weight of a container made from material of increased thickness. It is therefore an objective of this invention to provide a system embodying a relatively inexpensive, lightweight container and having means for re-enforcing the container and for the application of the tow force over a maximized surface area thereof. The last named means comprises a net-like towing assembly which enshrouds the container and includes both longitudinal and circumferential spoke-like elements which contact the container throughout substantially its full length and outer surface area.

Another objective of the invention relates to a novel container filling and evacuating method involving the exchange of fluid and gaseous media from and to the container, whereby the stability and ballast differential of the container is controlled during the loading and unloading operation.

A further object of importance resides in the provision of new and novel tow depth control means which permits towing of containers filled with fluids at controlled depths below the effective depth of wave action. Related to this objective is that of providing a further means for distribution of the tow force on the containers.

Still another advantage of the present invention concerns the provision of detachable ballast means. In this system, a saddle means with depending engagement means thereon overlies each container. As ballast is required, individual weights are releasably secured to the engagement means to thereby evenly distribute the ballast weight as required.

Other and further objects and advantages of the invention will become apparent to those skilled in the art from a consideration of the following specification when read in conjuntcion with the annexed drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of a portion of a typical towing arrangement for fluid containers embodying the principles of this invention and showing the tug vehicle and a buoyant vessel for the tow depth regulation means in phantom lines;

FIG. 2 is an enlarged elevational view of a portion of the depth regulation means, taken from the plane of the line 2—2 of FIG. 1, looking in the direction of the arrows;

FIG. 3 is a sectional view on an enlarged scale, taken on line 3—3 of FIG. 1, looking in the direction of the arrows;

FIG. 4 is an isometric view of a towed container hereof;

FIG. 5 is a perspective view of the container with its enveloping net structure in place in an operating position;

FIG. 5*a* is a rear end view of the assembly of FIG. 5;

FIG. 6 is a perspective view of the ballast means hereof;

FIG. 7 shows a lighter vessel and the ballast weights employed with the ballast means;

FIG. 8 is a fragmentary perspective view showing a modified load distribution member;

FIG. 9 is a fragmentary perspective view showing another modification of the load distribution member;

FIG. 10 is a perspective view showing a modification of the container tow connections; and

FIG. 11 is a transverse section on line **11—11** of FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 of the drawing is illustrative of a means for towing containerized fluids at sea. This system is intended for use principally in supplying very large quantities of fresh water, drawn from geographic areas of abundance, to arid zones or other places where usable fresh water is in short supply. It will however be understood that the method and apparatus of this invention is equally applicable to the transportation of other liquid or fluid substances, particularly those of a density such that they are naturally buoyant in sea water.

A container particularly suited to employment in the practice of this invention is shown apart from the remaining apparatus hereof in FIG. 4 of the drawing. The container is formed of non-rigid, flexible material, such as a nylon fabric impregnated with neoprene, or the like. The container must be of reasonably hydrodynamic form and is designated generally by reference character **10** of the drawing. The container **10** includes a main body section **12** of tubular form, and has a forward end section **14** and an aft end section **16**. The latter sections have generally truncated leading and trailing ends **18, 20**, respectively. Dimensions form no part of the invention, but by way of example and in illustration of a typical environment of use, the container shown is of a length of approximately 1,000 feet from end to end, and of a diameter of 100 feet. In this size range, a container of the generally cylindrical form shown and having semi-elliptical, flat ends, would have a gallonage capacity of approximately 62 million. Thus, with allowance for possible incompleteness of fill, a 10 container string of such containers would have a capability of transporting a cargo of approximately 600 million gallons.

The container could have hemispherical ends, which would be desirable for a container of circular cross-section. Or, it may have elliptical ends, these being desirable for containers of elliptical section.

Tow forces encountered by the containers **10** in use are very substantial. If a tow force were applied directly to a filled container at any single point, the system would become impractical inasmuch as a material of fabrication of vast strength would be required. In order to render it possible to make container **10** from relatively inexpensive and currently available materials, means is provided by this invention for distribution of the tow force over a maximum area thereof. This means comprises an enveloping net assembly. In FIG. 5, the net **22** is shown as applied to encase or enshroud the container **10**. The net is of nylon rope or other material of a favorable weight to pound test ratio, and includes a plurality of longitudinal strands **24** and a plurality of intermeshed encircling strands **26**. The longitudinal strands converge at **28** forwardly of the container and are thereat joined to a connector ring **30**. The longitudinal strands are also tied or otherwise affixed to a plurality of pickup lines **32** secured at circumferentially spaced locations at positions adjacent the forward end section of each container. Each pickup line **32** has an outer end connector **34** thereon, and the function of the pickup lines appears in more detail below.

The net assembly would be made smaller than the container enclosed thereby, so that any surges experienced by the cargo will be absorbed by the stretching capacity of the netting and no surge loads will have to be borne by the container material itself.

In FIG. *5a*, the aft end of the container is shown. There, the longitudinal strands **24** are shown as they converge at a rear collector ring **36** of reduced dimension, and it will further be seen that the encircling strands **24** continue in spaced relation fully to the ring **36**. The overall effect of the net is to distribute the tow force, and to confine the container against distortion or buckling when subjected to tow force from both the forward and aft ends, as arises by virtue of forces encountered in a towing operation. In the example given, it has been computed that a tow force in the range of 40 thousand pounds would be distributed over a container surface area of approximately 15,600 square feet in using this net system. Thus, the unit load on the container is held to an easily tolerable limit of approximately 2.5 pounds per square foot or .017 pound per square inch.

As a container **10** at rest in sea water is filled with fresh water, the differential and specific gravity between the container, contents and the surrounding sea water produces an undesirable buoyant force on the container. This upward force must be suitably counteracted in order to establish and maintain a desirable tow depth. Ballast means hereof comprise a blanket or saddle **38** shown in FIG. 6. Again as in the case of the tow shroud **22**, the ballast saddle **38** is of net form and includes transverse lines **40** and lengthwise lines **42**. The transverse lines have free ends **44, 46** supplied with suitable coupling means (not shown in detail) to receive filled ballast holders **48** containing sand or other readily available weight material. The number of holders **48** required varies with the load and with the stage of loading. Conveniently, the holders **48** are stored on a lighter or barge **50** adjacent the loading site. The lighter has crane means **52** and a supply of the holders. Each holder has a loop **54** or the like which is releasably engageable with a hook **56** on the crane means and with the unreferenced coupling means on the line ends **44, 46**. Thus, the holders may be applied to the ballast blanket as required and may also be readily removed.

Tow force for movement of the container alone or in series is a function of the displacement of the container, the velocity required, and a determined admiralty coefficient for the container. The tow force is preferably supplied by a sea-going tug vehicle **58** diagrammatically shown in FIG. 1 of the drawing. This tug vehicle **58** is economically a surface ship, and has the usual aft tow support **60**. Balancing of the container **10** at selected depths when at rest is not effective to retain this depth when the tow operation is commenced and the vehicle **58** is in motion, and it is necessary that the depth be sustained in order to avoid wave action. Depth regulation means **62** of the invention includes the buoyant vessel **64** towed by a first tow line **65** at a given distance behind the tug **58**. Mounted on the vessel **64** is a tubular, vertical element **66**. An extensible member **68** is mounted for vertical extension and retraction with respect to the tube **66**. A load distribution member **70** of somewhat annular form (here shown as of open square configuration) is fixably secured to the member **68** by means of straight rods **72, 74** extending from two of its vertically aligned corners to the said member, and by two angular rods **76, 78** which extend from its horizontally disposed corners.

The submersible towing means could be a submarine or a remotely controllable submersible power plant.

A main tow line **80** extends from the support **60** to an attachment **82** on the element **68**. A central tow line **84** extends from the juncture of rods **76, 78** of the load distribution member **70** to the connector ring **30** of the longitudinal strands of the net. Additional elongated tow lines **86** extend from the corners of the member **70**. The pickup lines **32** of the nets are connected to these lines

86 at the outer end connectors 34. Additional intermediate lines 88 extend between the rear collector rings 36 and the forward connector rings 30 of trailing containers in a series.

In the new and novel method of employing this apparatus herein contemplated, a supply of fresh water or other liquid adjacent a loading point for sea-going vessels is located and prearrangements for water loading are made. Initially, air is pumped into the container 10 to establish its configuration and to cause it to float on the water surface, it being understood that the tow netting and ballast netting are preapplied before inflation. A water pumping operation is then instituted, fresh water being introduced into the container as the air is simultaneously evacuated in a bleeding operation. When the container 10 is partially filled, ballast holders are brought alongside by the lighter and are suspended from the ballast netting. As the water pumping operation is substantially completed, the air bleeding is terminated, thus providing a small air space at the top of each container. The containers, as filled are staked at anchor until a train or series thereof is completed. In such condition, the containers are approximately 90% submerged and immediately prior to institution of the tow operation, the remaining air in the container is evacuated, thus submerging the containers in a substantially suspended, weightless condition. When the train of containers reaches a sufficient water depth, the element 68 is lowered and the entire train submerges to the depth set by the tow point on the annular ring. This can be varied as sea conditions and water depth require.

At a delivery point, the collector ring is raised and the water pumped from the container to a short reservoir area. If there is no return cargo, the containers 10, may merely be folded for storage back to the water transfer point.

In FIGURE 8 there is shown a modified load distribution number 70*a* of X-shape having crossed arms 72*a*, 74*a* fixedly secured to each other and to member 68. Lines 86 are connected to the ends of the arms. Central tow line 84 is connected to the center of member 70*a*.

FIG. 9 shows a load distribution member 70*b* of annular shape affixed at diametrically opposite locations thereon to member 68.

The load distribution members 70, 70*a*, and 70*b* can be used with the towline arrangement of FIG. 1, or alternatively, with a towline arrangement as in FIGS. 10 and 11, in which the center towline 84 and its associated collector ring 30 are omitted. This arrangement has the advantage that the fore-and-aft sections of the containers would be identical in shape and arrangement, as would the netting and the front and rear pickup lines 32. It is not essential in this arrangement that the containers be tied directly to one another, and all towing loads would be transmitted through the pickup lines 32.

What is claimed is:

1. Apparatus in a marine transport system, the apparatus comprising:
- a fluid container of hydrodynamic form;
- shroud means enveloping the container;
- a tow vehicle;
- tow depth regulation means including a submersible element, the tow vehicle being connected to the submersible element; and
- means connecting the submersible element to the shroud means;
- the depth regulation means comprising an extensible bar element suspended from a buoyant vessel towed by the tow vehicle and a load distribution ring on said bar element.

2. The invention of claim 1, wherein:
- the distribution ring has a plurality of trailing tow lines;
- the throud means includes a group of outwardly extendable pickup lines; and

- the pickup lines are connected to the trailing tow lines.

3. The invention of claim 2, wherein:
- the fluid container is of flexible material and has a generally cylindrical main body section with semi-elliptical forward and aft ends;
- the shroud means comprises a plurality of longitudinal strands and encircling strands; and
- the respective strands extend in spaced locations about the full surface area of the fluid container.

4. Apparatus in a marine transport system, the apparatus comprising:
- a fluid container of hydrodynamic form;
- shroud means enveloping the container;
- a tow vehicle;
- tow depth regulation means including a submersible element, the tow vehicle being connected to the submersible element; and
- means connecting the submersible element to the shroud means;
- the fluid container being of flexible material, the shroud means comprising a plurality of longitudinal strands and a plurality of encircling strands, the ballast means comprising a saddle overlying the container and shroud and having releasable weights suspended on opposite sides thereof.

5. Apparatus in a system for the transportation of materials by sea, the system involving the towing of container means by a tug vehicle, the apparatus comprising:
- at least one non-rigid container of a series thereof, of generally cylindrical form having a tubular main body and forward and aft ends;
- the forward end being of generally semi-elliptical form to reduce the resistance of sea water to the passage of the container therethrough;
- a net enveloping the container, the net including longitudinal strands and intermeshed encircling strands, and having outward pickup lines radially extendable therefrom;
- the longitudinal strands converging to a connector element adjacent the forward end of the container, and converging to a second connector ring located adjacent the aft end of the container;
- the strands distributing the tow force over a maximum area of the container;
- ballast means overlying each container and net, the ballast means comprising saddles formed of a non-rigid material adherent to the configuration of the container and net, the saddle having sides;
- weights releasably connected to the sides of the saddle, the weights being of pre-determined weight to suspend the container at a selected depth;
- depth regulation means comprising a buoyant vessel, a vertical tube mounted on the vessel, and an extensible element operatively associated with the tube;
- a tow load distribution member rigidly secured to the extensible element, the distribution member being generally annular and having multiple line attachment points thereon;
- a control tow line extending from the member to the connector element adjacent the forward end of a leading container in the series;
- a plurality of secondary outer tow lines extending from said line attachment points of the tow member, the pickup lines being connected thereto;
- first tow line means connecting the bouyant vessel and the tug vehicle; and
- second tow line means connecting the tug vehicle and the extensible element.

6. A method of transporting fresh water at sea comprising:
- filling a non-rigid container with a floatable gaseous medium to float the container on the sea surface adjacent a supply of fresh water;
- attaching a tow net and a ballast saddle to the container;

pumping fresh water from said supply into said container and simultaneously exhausting said gaseous medium in corresponding volume to a level of substantially 90% of filling of the container with fresh water;

attaching ballast to said ballast saddle as the container is filled with water to establish a selected towing depth for the container;

exhausting the remaining gaseous medium from the container whereby the container becomes substantially suspended in sea water;

submerging an extensible tow element from a buoyant vessel to a desired tow depth below the wave action of the sea water;

establishing a tow connection between the tow element and the tow net; and

connecting a tug vehicle to the buoyant vessel and the tow element.

7. Apparatus in a marine transport system, the apparatus comprising:

a fluid container of hydrodynamic form;

shroud means enveloping the container;

a tow vehicle;

tow depth regulation means including a submersible element, the tow vehicle being connected to the submersible element; and

means connecting the submersible element to the shroud means, comprising a plurality of trailing tow lines connected to the submersible element in angularly spaced relation and extending longitudinally of the container in radially outwardly spaced relation thereto, and a plurality of pickup lines extending radially from the container and connected between the shroud means and the respective tow lines.

8. Apparatus as in claim **7** wherein said pickup lines are arranged in a first and second series connected to the shroud means at the fore and aft ends, respectively, of the container.

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TRYGVE M. BLIX, Primary Examiner

U.S. Cl. X.R.

114—74