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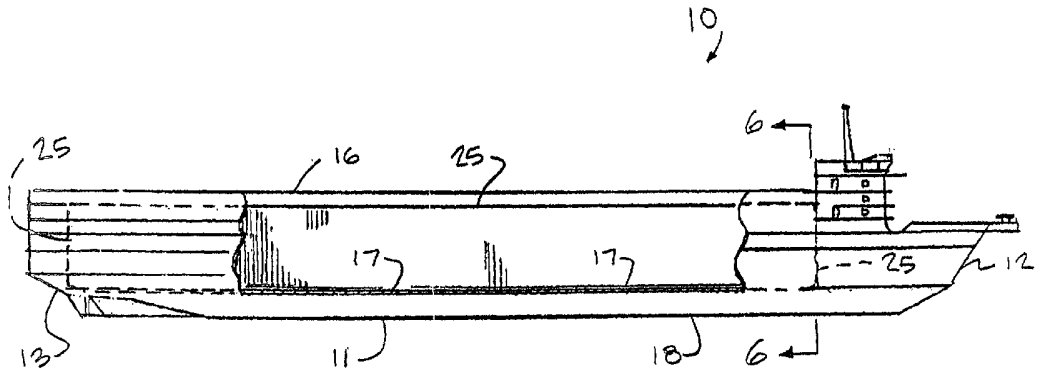
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(54) **Title:** METHOD AND APPARATUS FOR TRANSPORTING COMPRESSED NATURAL GAS IN A MARINE ENVIRONMENT



(57) **Abstract:** A method and apparatus for transporting or storing compressed natural gas in a marine environment includes the providing of a heavy lift vessel that has a weather deck area that is bounded by forward and aft, port and starboard sides or walls that extend above the weather deck. A buoyant module is provided that contains a pipeline, the pipeline including multiple bends and multiple layers. The pipeline is supported at differing elevations within the module interior so that the various sections of the pipeline are preferably spaced apart to enable visual and/or remote exterior inspection (*e.g.* video, radar, x-ray, acoustic, or other exterior, non-destructive test) of the outer surface of the pipeline. The pipeline has a continuous bore that is piggable for internal inspections. The module can be transferred to a heavy lift vessel or can be used as flotation. The combination of heavy lift vessel and module can travel to a selected location for loading and unloading compressed natural gas. The module can be placed in a marine environment to serve as a storage facility for compressed natural gas.

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TITLE OF THE INVENTION

"Method and Apparatus for Transporting Compressed Natural Gas in a Marine Environment"

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CROSS-REFERENCE TO RELATED APPLICATIONS

Priority is hereby claimed to US provisional application serial number 60/391,276, filed on 25 June 2002.

US provisional application serial number 60/391,276, filed on 25 June 2002, is incorporated herein by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND

1. Field

The present invention relates to storage and transportation of compressed natural gas under pressure in a self-sustaining module housing a continuous pipeline. The modular system can be used for the storage of compressed natural gas in a marine environment or in a terrestrial environment. Moreover, through the use of a specially configured new, purpose built, or existing, semi-submersible heavy lift vessel, heavy lift vessel or other special built transport vessel (collectively herein also referred to as "transport vessel"), the modular system can also be used for transportation of compressed natural gas in a marine environment. A heavy lift vessel is designed to carry very large, bulky cargoes on an open deck and a semi-submersible vessel is designed with a ballast system to enable the cargo deck or weather deck to submerge below the water, allowing the floating cargo to be positioned over the weather deck area and secured on the deck

when the vessel is de-ballasted and the deck rises above the water.

More particularly, the present invention relates to an improved method and apparatus for 1) storage of compressed natural gas in a module housing a pipeline at the source of natural gas, 2) transportation of compressed natural gas using a specially configured new, purpose built, or existing, semi-submersible heavy lift vessel, heavy lift vessel or other special built transport vessel that carries such module housing a pipeline and 3) offloading and storage of compressed natural gas in a module housing a pipeline at the terminal location or destination, while the module is 1) in a floating mode on the surface of the water, or 2) suspended beneath the surface of the water, or 3) supported with a specially configured new, purpose built, or existing vessel. The module can be transferred to or from the marine transport or storage vessel from a dock or from an adjacent waterway having sufficient draft to float the module and to float the specially configured new, purpose built, or existing, semi-submersible heavy lift vessel or other special built transport vessel (herein also referred to as"transport vessel"). The module may also be removed from the marine transport vessel and utilized for free standing storage of compressed natural gas on land or in a marine environment either on the surface or submerged below the water surface. The module has an interior with a continuous pipeline comprised of metal and/or light weight composite material that includes multiple layers, each layer having generally straight sections and curved sections that are preferably formed by induction bending of the metal pipe, with or without composite reinforcing, or custom built using only light weight composite material, or a combination of metal and light weight composite material. The contained pipeline is continuous and is supported, in layers, by a pipe support system that is also the subject of this invention.

2. General Background

Marine vessels have been used to transport compressed gas in the medium known as liquid petroleum gas (LPG) typically in a mixture of c2, c3, and c4 linear saturated hydrocarbons at a relatively low pressure and at ambient temperature. In such a situation, the marine vessel typically has a plurality of containers that carry the compressed gas.

In the prior art, ship based systems have been proposed for transporting compressed natural gas (comprising chiefly methane (c1) with small quantities of c2 through c4 saturated hydrocarbons). Such systems have typically proposed a plurality of

containers that are in fluid communication using a manifold system. One system employs a spool with pipe wrapped upon the spool, each layer contacting the previous layer.

An example of a ship based system for a compressed natural gas transport is US Patent 5,803,005 issued to Stenning et al. The Stenning '005 patent discloses a ship based system for compressed natural gas transport that utilizes a ship having a plurality of gas cylinders. The plurality of gas cylinders are configured into a plurality of compressed gas storage cells. Each compressed gas storage cell consists of between 3 and 30 gas cylinders connected by a cell manifold to a single control valve. A high pressure manifold is provided including means for connection to shore terminals. A low pressure manifold is provided including means for connection to shore terminals. A sub manifold extends between each control valve to connect each storage cell to both the high pressure manifold and the low pressure manifold. Valves are provided for controlling the flow of gas through the high pressure manifold and the low pressure manifold.

Two additional Stenning et al. patents have issued that are directed to a ship based gas transport system. These include US Patents 5,839,383 and 6,003,460. In the Stenning '383 and '460 patents, a gas storage system formed of continuous pipe is wound in plural layers, each layer having plural loops. The pipe is said to be distributed within a container, which may serve as a carousel for winding the pipe and as a gas containment device. When containers, each containing a continuous pipe are stacked upon each other, the weight of upper containers is said to be born by the walls of lower containers, thus preventing lower layers of pipe from suffering stresses due to crushing by upper layers. The Stenning '383 and '460 patents disclose a method of transporting gas to a gas distribution facility including obtaining a supply of gas at a gas supply point remote from the gas distribution facility, injecting the gas into a continuous pipe bent to form plural layers, each layer including plural loops of pipe, transporting the continuous pipe along with the gas to the gas distribution facility preferably in a ship and discharging the gas at the gas distribution facility. It is preferred that cooling of the pipe during discharging of the gas be conserved so that during subsequent filling the pipe is initially cool. During filling, the gas pressure is said to be maintained as constant as possible for example by controlled release of an incompressible liquid from the pipe as the pipe is filled with gas. Energy from the incompressible liquid may then be recovered or dissipated outside of the pipes.

A report entitled "Clarification of Certain Issues Pertaining to the Marine Transportation of C.N.G." was prepared for Entergy Power Group by Bill Bishop, then of PB-KBB, an engineering firm with offices in Houston, Texas, in August of 1995. The Bishop report provides a design of a pipe storage transportation system for gas. The report also considers the option of using a ship or a barge for this purpose.

US Patent application No. 2002/0046457A1 was published April 25, 2002, naming inventors as William Bishop, Charles White and David Pemberton. The published Bishop et al. patent application discusses methods and apparatus for transporting compressed gas. The methods and apparatus for transporting compressed gas include a gas storage system having a plurality of pipes connected by a manifold whereby the gas storage system is designed to operate in the range of the optimum compressibility factor for a given composition of gas. The pipe for the gas storage system is said to be preferably large diameter pipe made of a high strength material whereby a low temperature is selected which can be withstood by the material of the pipe. This publication states that by knowing the compressibility factor of the gas, the temperature, and the diameter of the pipe, the wall thickness of the pipe may be calculated for the pressure range of the gas at the selected temperature. The publication states that the gas storage system may either be modular or be part of the structure of a vessel for transporting the gas to the storage system. Since the pipe provides a bulkhead around the gas, the gas storage system may be used in a single hull vessel. The gas storage system further includes enclosing the pipes in a chilled nitrogen atmosphere. A displacement fluid may be used to offload the gas from the gas storage system. A vessel with the gas storage system designed for a particular composition gas produced at a given location is used to transport gas from that producing location to offloading ports hundreds, or thousands, of miles from the producing location.

BRIEF SUMMARY

The present invention provides an improved method and apparatus for transporting compressed natural gas in a marine environment and storing compressed natural gas in a marine environment or terrestrial environment. The method of the present invention includes the step of providing a heavy lift vessel that has a weather deck or lower deck area. This weather deck or lower deck is bounded by port and starboard sides that extend above the weather or lower deck.

A hollow buoyant module is provided that contains a continuous pipeline, the pipeline including multiple layers, each layer having alternating straight pipe sections and bend sections. The pipeline can be continuous pipeline or comprised of various joints of pipe. Preferably the pipeline will have a bore of a substantially constant diameter. The pipeline can include multiple substantially straight metal pipe sections having bends at either end portion that are formed using induction bending. The pipeline can include straight or bend sections manufactured using metallic pipe wrapped with light-weight, high strength composite materials composed of carbon fiber, fiberglass , aramid or other high tensile strength filaments bound by polymeric resin.

The pipeline can include straight or bend sections manufactured using light-weight, high strength composite materials composed of carbon fiber, fiberglass , aramid or other high tensile strength filaments bound by polymeric resin.

The multiple pipeline layers are supported at differing elevations within the module. The module can then be transferred to the transport vessel. The transport vessel, equipped with module and pipeline, can then travel to a natural gas source and be loaded with compressed natural gas.

In the preferred embodiment, the transfer of the module to the semi-submersible heavy lift vessel includes the step of ballasting the semi-submersible heavy lift vessel and module relative to one another.

In the method of the present invention, the buoyant module preferably provides a top, bottom and a plurality of side walls.

In the preferred method, the transport vessel is a semi-submersible heavy lift vessel and the method includes ballasting the semi-submersible heavy lift vessel relative to the module when the module is to be loaded on the transport vessel or unloaded from the transport vessel.

Ballasting of the semi-submersible heavy lift vessel is preferably used to lower the weather deck a selected distance so that the weather deck is submerged and the module can be safely floated over the weather deck for transfer to the semi-submersible heavy lift vessel. The semi-submersible heavy lift vessel then can be de-ballasted up until the weather deck area is above sea level. In this position, the weather deck supports the module so that the combination of semi-submersible heavy lift vessel and module can travel to or from a selected natural gas source.

In one embodiment, the method of loading the module can include sliding the module from land to the semi-submersible heavy lift vessel weather deck area.

In another embodiment, the method of loading involves lifting multiple modules into a purpose-built, non-semi-submersible hull, utilizing a lifting device or devices that provide, e.g. external crane capacity.

In the method of the present invention, the module may be unloaded from the semi-submersible heavy lift vessel by ballasting methods in the water or by sliding the module onto land, in a reverse operation from the loading steps described above. Thereafter, the module may be used for static storage in a permanent or semi-permanent location on land or on the surface of the water or underwater, either suspended below the surface or resting on the bottom of the waterway, lake, bay or ocean.

BRIEF DESCRIPTION OF THE DRAWINGS

For a further understanding of the nature, objects, and advantages of the present invention, reference should be had to the following detailed description, read in conjunction with the following drawings, wherein like reference numerals denote like elements and wherein:

Figure 1 is an elevation view of the preferred embodiment of the apparatus of the present invention;

Figure 2 is a plan view of the preferred embodiment of the apparatus of the present invention;

Figure 3 is a partially cut away plan view of the preferred embodiment of the apparatus of the present invention;

Figures 4-5 are schematic views illustrating pipe layer arrangements for use with the preferred embodiment of the apparatus of the present invention;

Figure 6 is a sectional view taken along lines 6-6 of Figure 1;

Figure 7 is a perspective view of the preferred embodiment of the apparatus of the present invention showing transfer of the module to the semi-submersible heavy lift vessel at a dock;

Figure 8 is a perspective view of the preferred embodiment of the apparatus of the present invention showing transfer of the module to the semi-submersible heavy lift vessel at a dry dock;

Figure 9 is a perspective view of the preferred embodiment of the apparatus of the

present invention showing transfer of the module from a marine transport vessel to a storage position on land;

Figure 10 is a perspective view of the preferred embodiment of the apparatus of the present invention showing transfer of the module from the semi-submersible heavy lift vessel to land wherein the module is located in a final storage position;

Figures 11 is a perspective fragmentary view of the preferred embodiment of the apparatus of the present invention showing the pipe support in detail;

Figure 12 is a fragmentary view of the preferred embodiment of the apparatus of the present invention showing an alternate pipe support;

Figure 13 is a schematic view illustrating pipe sections and field welds for one of the pipe layers;

Figure 14 is a schematic plan view illustrating field welds for one of the layers;

Figure 14A is a fragmentary view showing an about 180 degree induction bend part of the module pipeline;

Figure 15 is a perspective fragmentary view illustrating attachment of the semi-submersible heavy lift vessel of the present invention to a known mooring and unloading arm;

Figure 16 is a schematic view illustrating the top layer pipe layout for a barge type module;

Figure 17 is a schematic view illustrating the second and fourth layers of the pipe layout for a barge type module;

Figure 18 is a schematic view illustrating the third and fifth layers of the pipe layout for a barge type module;

Figure 19 is a schematic view illustrating the sixth layer for a pipe layout for a barge type module; and

Figure 20 is a fragmentary, sectional view of the preferred embodiment of the apparatus of the present invention showing barge module and pipeline.

DETAILED DESCRIPTION

Figures 1-2 and 7-8 show generally the preferred embodiment of the apparatus of the present invention designated generally by the numeral 10. Compressed gas transport apparatus 10 includes a semi-submersible heavy lift vessel 11 that has a bow 12, stern 13, port side 14, starboard side 15, upper deck 16 and lower or weather deck 17.

The semi-submersible heavy lift vessel 11 also includes a hull bottom 18, port deck wall 19 and starboard deck wall 20. A space 24 is provided between port deck wall 19, starboard deck wall 20 and above weather deck 17 for carrying module 25. A module 25 can be carried by the semi-submersible heavy lift vessel 11. Module 25 can be inserted into or removed from space 24. Module 25 can be a floating hull such as a barge. Module 25 provides an interior 32 that carries a module pipeline 45. The pipeline 45 includes multiple sections that are joined together end to end by welds in the case of metal materials, or by polymeric adhesives or mechanical joints in the case of composite pipe materials. Pipeline 45 includes multiple layers, such as the eight layer arrangement shown in figures 3-6. Another eight layer arrangement is shown in figures 16-19.

In order to load module 25 upon semi-submersible heavy lift vessel 11, two options are shown in the drawings in Figures 7 and 8. In Figure 7, a load out is shown using rails, skidways or skid beams 23. The semi-submersible heavy lift vessel 11 is positioned next to land 21, floating in water 22 and ballasted so that the lower or weather deck 17 is at about the same elevation as the elevation of land 21 upon which module 25 rests. Arrow 26 in Figure 7 illustrates the sliding movement of module 25 upon beams 23 from land 21 to lower or weather deck 17 of semi-submersible heavy lift vessel 11.

In Figure 8, a second method of transporting the module 25 from land to heavy lift vessel 11 is shown. In Figure 8, module 25 is shown in a graving dock or dry dock 70 having a gate 71 that can be closed to prevent water from entering the dry dock 70 such as during construction of module 25. The gate 71 can be opened to flood the dry dock 70 so that module 25 floats. Module 25 can then be moved in the direction of arrows 28-31 from an initial position inside dry dock 70 to the adjacent body of water 22 and then to lower deck 17 of semi-submersible heavy lift vessel 11. During this transfer, semi-submersible heavy lift vessel 11 is ballasted down a distance that submerges lower deck 17 so that the module 25 can be floated into an area 24 that is directly above lower or weather deck 17 and in between port deck wall 19 and starboard deck wall 20. The semi-submersible heavy lift vessel 11 is then de-ballasted up until lower deck 17 is above sea level and water surface 27. The vessel 11 and its contained module 25 can travel to a selected source of contained compressed natural gas. The module 25 can be filled with compressed natural gas at the selected source, and then travel to its ultimate destination for unloading.

Figure 9 and 10 illustrate an unloading of a module 25 from vessel 20. The embodiments shown in figures 9 and 10 show method steps that are utilized when the module 25 is to be unloaded from the semi-submersible heavy lift vessel 11 by ballasting the water or by sliding as shown in figures 8 and 9 in a reverse operation from the loading steps of figure 7. Winch 31 can pull module 25 from vessel 11 to land 21 as it slides upon rails 23. In figure 10, the module 25 may be used for static storage in a permanent or semi-permanent location on land 21 while on the surface of the water 22 or suspended below the surface of the water, or on the bottom.

In Figures 6-8, and 11-12 module 25 has a module interior 32 that contains pipeline 45. Module 25 can be shaped to include a bottom 34, top 33, port side 35, starboard side 36, bow 37 and stern 38. A plurality of longitudinally extending bulkheads 39 can be provided as shown in Figure 11. Reinforcing can be provided to module 25 under the pipeline 45 and above bottom 34, including a plurality of diagonal braces 49 and a plurality of vertical braces 50.

The pipeline layers are supported by a plurality of pipe supports 40. As shown in Figures 11-12, each pipe support 40 includes a web 41, upper flange 42, and lower flange 43. A curved bearing pad 44 is sized and shaped to conform to the outer surface 46 of the pipeline 45. As shown, the pipeline 45 is cradled with two pipe supports 40, one placed under the pipeline 45 at a selected location and one placed above the pipeline at about the same location. The pipeline 45 has an outer surface 46, a pipeline bore 47 for holding compressed natural gas and is comprised of a plurality of straight sections and bend sections as shown in Figures 3-5 and 13-20. When a plurality of the pipe supports 40 are assembled as shown, a plurality of circular openings 48 are provided through which a section of pipeline 45 passes.

Figure 12 shows a non-metallic (e.g. polymeric) support 40A having upper surface 41A with bearing pads 44A, lower surface 43A, and opposing generally vertical end faces 41B. Alternatively, the pipeline can be supported by a mass of encapsulating polymeric material (e.g. sprayed) that both supports and insulates the pipeline 45. Thus, the entire interior 32 of the module 25 could be filled with an insulating material. If pipe supports 40, 40A are used (figures 6, 11, 12, 20), the interior 32 of module 25 could be filled with an inert gas. If the interior 32 of module 25 is to be filled with inert gas, weep holes 80 (see figures 11 and 12) can be provided in the selected pipe support 40 or 40A

as shown. These weep holes 80 insure that the inert gas will flow freely throughout the entire interior 32 of module 25.

In the embodiment shown in Figures 3-6, there are eight layers of pipe sections. A plurality of the pipe layers are similarly configured. For example, in figure 3, the pipe layout for the first and fifth layers 51 can be substantially identical. The pipe layer 52 (figure 4) for the second, fourth, sixth and eighth layers can be substantially identical. The pipe layer 53 (figure 5) for the third and seventh layers can be identical. In the sectional view of Figure 6, cross overs 54-60 are shown for connecting a pipe layer to the pipe layer above it. Each of the layers of pipe 51, 52, 53 includes longitudinal straight sections, transverse straight sections, and bend sections. A cross over is a section of pipe that extends from one layer to another layer that is either above or below it.

As part of the method of the present invention, sections of pipe can be prefabricated to provide either an asymmetric bending of metal pipe or pipe that is custom built from light weight composite material, in the case of 90 degree bends; or a symmetric bend section using induction bending of metal pipe or pipe that is custom built from light weight composite material, in the case of 180 degree bends. A section of pipe that is, for example, 40 or 50 or 60 feet(12.2 or 15.2 or 18.3 meters) long is induction bent, in case of metal, or custom built with a bend (in case of composite material), at one end portion to provide a prefabricated bend. The prefabricated pipe section containing a bend and one or more long straight pieces (e.g. 68, 68A) will obviate the need for attaching an elbow fitting to any particular pipe section in the assembly of the module in the field. Welding of metal or connecting composite pieces of pipe is required when the asymmetric pipe sections 68 are connected together or to straight pipe sections 72.

Figures 13-14, 14A illustrate the various asymmetric sections 68, 68A of pipe having induction bends 69 before they are to be assembled together with straight pipe sections 72 using field welds or composite connections at 73. In Figures 13 and 14, pipe can be cut from an elongated string of pipe sections that are connected together. For example, in the case of metal, various pieces of pipe can be welded end to end to form a pipeline stalk of about 450 feet(137.2 meters) in length. In the case of composite, pipe can be made up in desired lengths to minimize the number of connections. In this fashion, each of the different straight sections 72 can be cut to a preferred length before field welding of metal or connection of composite materials. In the case of a 180 degree

symmetric bend section 68A (figure 14A), the same applies.

In order to load or offload compressed natural gas, a mooring or unloading arm 66 can be provided. Such mooring/ unloading arms 66 are known in the art. They can be carried on board fixed or floating structures 67 including F.P.S.O.s (floating production storage and off-loading). A fitting 65 on the vessel 11 enables a connection to be made between pipeline 45 and mooring unloading arm 66.

A module can be placed on the FPSO for the purpose of providing storage of compressed natural gas from oil and gas production at an offshore location.

A module can be placed on the surface of the water or submerged below the surface for the purpose of providing storage of compressed natural gas.

In Figures 16-20, an alternate pipe and module arrangement 74 is shown in the form of a barge module 75 utilizes a generally rectangular barge that has exemplary dimensions of 100 feet (30.5 meters) wide and 400 feet(121.9 meters) long. In Figures 16-20, the pipeline 76 is of a plurality of six layers stacked directly one upon the other in order to minimize vertical stacking and maximize payload. In Figure 16, layer 76 is a first and top layer. Layer 77 (figure 17) is the same for the second and fourth layers. Layer 78 (figure 18) is the same configuration for the third and fifth layers. Layer 79 (figure 19) is the configuration for the sixth layer.

LIST OF REFERENCE NUMERALS

The following is a list of reference numerals for various elements of the preferred embodiment.

10	compressed natural gas transport
11	semi-submersible heavy lift vessel
12	bow
13	stern
14	port side
15	starboard side
16	upper deck
17	lower deck
18	hull bottom
19	port deck wall
20	starboard deckwall

21	land
22	water
23	skid beams
24	space
25	module
26	arrow
27	water surface
28	arrow
29	arrow
30	arrow
31	arrow
32	module interior
33	top
34	bottom
35	port side
36	starboard side
37	bow
38	stern
39	bulkhead
40	pipe support
40A	support
41	web
41A	upper surface
41B	opposing face
42	upper flange
42A	upper surface
43	lower flange
43A	lower surface
44	bearing pad
44A	bearing pad
45	pipeline
46	outer surface

47	pipeline bore
48	circular opening
49	diagonal brace
50	vertical brace
51	pipe layer
52	pipe layer
53	pipe layer
54	cross over
55	cross over
56	cross over
57	cross over
58	cross over
59	cross over
60	cross over
61	longitudinal straight section
62	transverse straight section
63	bend section
64	mooring arm connecting end
65	fitting
66	mooring/unloading arm
67	fender
68	asymmetric pipe section
69	induction bend
70	dry dock/graving dock
71	gate
72	straight section
73	field weld
74	pipe arrangement
75	module
76	pipeline layer
77	pipeline layer
78	pipeline layer

79	pipeline layer
80	weep hole
31	winch
82	arrow

The foregoing embodiments are presented by way of example only; the scope of the present invention is to be limited only by the following claims.

CLAIMS

1. A method of transporting natural gas in a marine environment, comprising the steps of:

a) providing a heavy lift vessel that has a weather deck area;

b) providing a buoyant module having an interior that contains a pipeline, said pipeline including multiple alternating straight sections and bend sections and multiple layers; and

c) supporting the multiple pipeline layers at different elevations within the module interior;

d) transferring the module to the heavy lift vessel;

e) transferring natural gas from a natural gas source to the module pipeline;

f) transporting the combination of module and heavy lift vessel to a selected destination while the module containing natural gas occupies the weather deck; and

g) transferring the natural gas from the module pipeline to a selected facility.

2. The method of claim 1 wherein the buoyant module has a top, bottom, and a plurality of side walls.

3. The method of claim 1 wherein step "d" includes ballasting of the heavy lift vessel relative to the module.

4. The method of claim 1 wherein the heavy lift vessel is a semi-submersible heavy lift vessel and step "d" includes ballasting the heavy lift vessel.

5. The method of claim 4, further comprising ballasting the heavy lift vessel down a distance that submerges the weather deck and further comprising the steps of floating the module to a position above the weather deck and ballasting the heavy lift vessel and module relative to one another until the weather deck supports the module above sea level.

6. The method of claim 5 wherein the vessel deck area submerges in step "d" a distance of between about 180 and 610 centimeters.

7. The method of claim 5, further comprising de-ballasting the vessel up while the module is floating above the receptacle deck area.

8. The method of claim 1 wherein step "d" includes sliding the module from land to the vessel weather deck area.

9. The method of claim 1 wherein step "d" includes sliding the module from

a dock to the vessel weather deck area.

10. A method of transporting compressed natural gas in a marine environment, comprising the steps of:

a) providing a heavy lift vessel that is capable of moving under its own power in a marine environment to a location that has a compressed natural gas facility with natural gas to be transported;

b) providing a module having a hollow interior and a pipeline;

c) filling the module pipeline with compressed natural gas;

d) transporting the module with compressed natural gas inside the pipeline using the vessel; and

e) wherein ballasting and de-ballasting is used to place the module on the vessel in steps "a"-"d".

11. A method of storing compressed natural gas in a marine environment, comprising the steps of;

a) moving a heavy lift vessel or a barge under its own power in a marine environment to a location that has a compressed natural gas facility with natural gas to be transported;

b) providing a module having a hollow interior and a pipeline;

c) filling the module pipeline with compressed natural gas;

d) storing the compressed natural gas;

e) Discharging and offloading the compressed natural gas; and

f) wherein ballasting is used to place the module on the vessel in steps "a"-"d".

12. A method of storing compressed natural gas in a marine environment, comprising the steps of;

a) moving a heavy lift vessel under its own power in a marine environment to a location that has a compressed natural gas facility with natural gas to be transported;

b) providing a module having a hollow interior and a pipeline;

c) Ballasting the heavy lift vessel and offloading the module into the water at the storage location;

d) filling the module pipeline with compressed natural gas;

e) storing the compressed natural gas until it is offloaded into a compressed

natural gas carrier or a pipeline; and

f) wherein ballasting is used to place the module on the vessel and off the vessel in steps "a"-"d".

13. A method of transporting a compressed natural gas module in a marine environment and storing compressed natural gas on land, comprising the steps of:

a) moving a heavy lift vessel under its own power in a marine environment to a location that is to receive compressed natural gas;

b) providing a module having a hollow interior and a pipeline;

c) backing the heavy lift vessel to the dock and offloading the module at the storage location;

d) filling the module pipeline with compressed natural gas;

e) storing the compressed natural gas until it is offloaded into a compressed natural gas carrier or a pipeline; and

f) wherein ballasting is used to place the module on the vessel in "a"-"f".

14. The method of claim 10 wherein step "b" includes prefabricating parts of the pipeline in pieces to maximize the lengths of pieces and to minimize the number of connections in the assembly of the pipe module.

15. The method of claims 10 wherein step "b" includes connecting pieces of metal pipe by field welding end on end the sections together during a fabricating of the pipeline (into sections), and placing the pipeline inside the module.

16. The method of claim 10 wherein step "b" includes connecting pieces of composite pipe in the field by applying adhesive binding to sleeve joints of composite pipe.

17. The method of claim 10 wherein step "b" includes connecting pieces of composite pipe with rotating mechanical locking joints on each end, with the straight piece turning in one direction and locking at both ends.

18. The method of claim 15 wherein in step "b" the pipeline is fabricated of a plurality of straight sections and a plurality of bend sections.

19. The method of claim 15 wherein in step "b" the pipeline is fabricated of sections that have bends that are made with induction bending.

20. The method of claim 13 wherein at least one of the bends is an about 90 degree bend.

21. The method of claim 20 wherein there are multiple about 90 degree bends.

22. The method of claim 13 wherein at least one of the bends is an about 180 degree bend.

23. The method of claim 13 wherein at least one of the bends is an about 90 degree bend and another of the bends is an about 180 degree bend.

24. The method of claim 21 wherein at least one straight section of pipe has two end portions that each have a bend.

25. The method of claim 22 wherein at least one straight section of pipe has an end portion that has a bend of between about 90-180 degrees.

26. The method of claim 22 wherein at least one straight section of pipe has a pair of end portions that have a bend of between about 90-180 degrees.

27. The method of claim 15 wherein the pipeline has a diameter of between about 16 and 56 inches.

28. The method of claim 14 further comprising supporting the pipeline with a plurality of racks that cradle and space apart separate sections of the pipeline.

29. The method of claim 14 further comprising constructing the pipeline of step "b" of a plurality of generally straight sections and a plurality of bend sections and further comprising the step of supporting each generally straight pipe section at a position spaced away from the other pipe sections.

30. The method of claim 14 further comprising constructing the pipeline of step "b" of a plurality of generally straight sections and a plurality of bend sections and further comprising the step of supporting each bend pipe section at a position spaced away from the other pipe sections.

31. The method of claim 18 wherein the racks include pipe support surfaces that are shaped to continuously engage and cradle a part of the pipeline.

32. The method of claim 24 wherein the pipe support surfaces include low friction bearing material.

33. The method of claim 1 wherein the pipeline has a continuous bore that is piggable.

34. The method of claim 10 wherein the pipeline has a continuous bore that is piggable.

35. The method of claim 1 wherein the pipeline sections are spaced apart so

that exposed outer surfaces of the pipeline sections can be visually inspected.

36. The method of claim 10 wherein the pipeline sections are spaced apart so that exposed outer surfaces of the pipeline sections can be visually inspected.

37. The method of Claim 1 or 10 wherein the module interior is filled with inert gas.

38. The method of claim 37 wherein the inert gas is CO_2.

39. The method of claim 37 wherein the inert gas is nitrogen.

40. The method of claim 37 wherein the inert gas is argon.

41. The method of claim 37 wherein the inert gas is any fully oxidized gas compound.

42. The method of claim 37 wherein the gas is chilled to a temperature between about minus 30°F and 0°F.

43. A natural gas pipeline module transport or storage apparatus comprising:

a) a module having an interior;

b) a pipeline contained within the module interior, the pipeline having a bore;

c) a marine vessel for transporting or supporting the module;

d) wherein the module rests upon a deck of the vessel; and

e) wherein the pipeline has multiple layers, each layer having multiple bends and multiple straight sections that enable the pipeline to extend over substantially all of the interior.

44. The transport apparatus of claim 43 wherein the vessel is either a heavy lift transport vessel or a semi-submersible transport vessel.

45. The transport or storage apparatus of claim 1 wherein the vessel is either a new purpose build vessel or an existing vessel.

46. The transport or storage apparatus of claim 46 further comprising one or more valves for isolating portions of the pipeline.

47. The transport or storage apparatus of claim 33 wherein the valves have a bore that is about the same diameter of the pipeline bore.

48. A natural gas pipeline module transport or storage apparatus comprising:

a) a floating module having an interior;

b) a pipeline contained within the module interior, the pipeline having a bore; and

c) wherein the pipeline has multiple layers, each layer having multiple bends and multiple straight sections that enable the pipeline to extend over substantially all of the interior.

49. The transport or storage apparatus of claim 43 further comprising pipe supports for supporting the pipeline inside the module.

50. The transport or storage apparatus of claim 49 wherein the pipe supports are metallic.

51. The transport or storage apparatus of claim 49 wherein the pipe supports are non-metallic.

52. The transport or storage apparatus of claim 49 wherein the pipe supports are polymeric.

53. The transport or storage apparatus of claim 49 wherein the pipe supports are support members having curved support surfaces that cradle the pipeline.

54. The transport or storage apparatus of claim 49 wherein the pipe supports are support members having curved support surfaces that cradle the pipeline in positions that space sections of the pipeline apart.

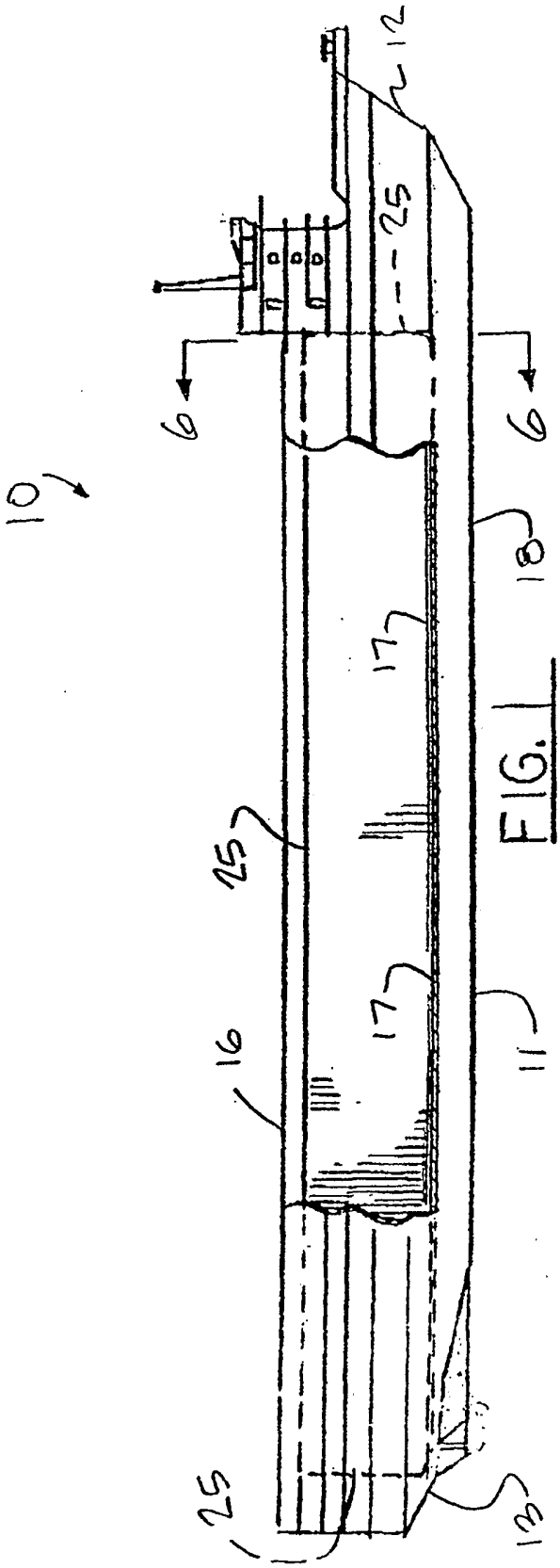


FIG. 1

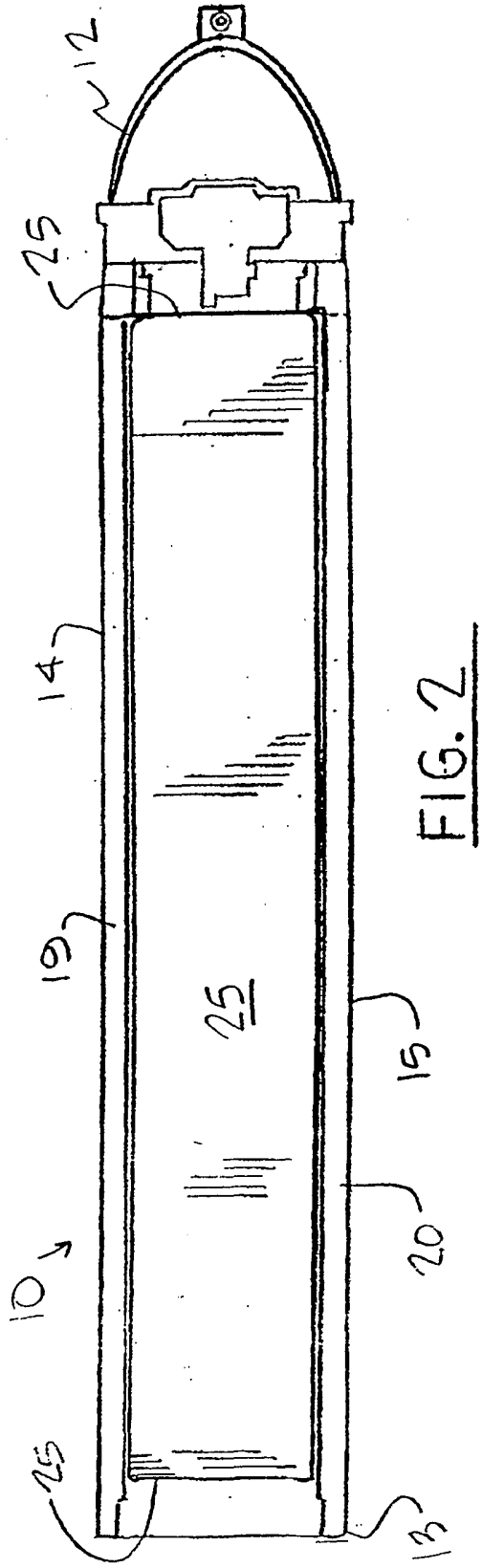


FIG. 2

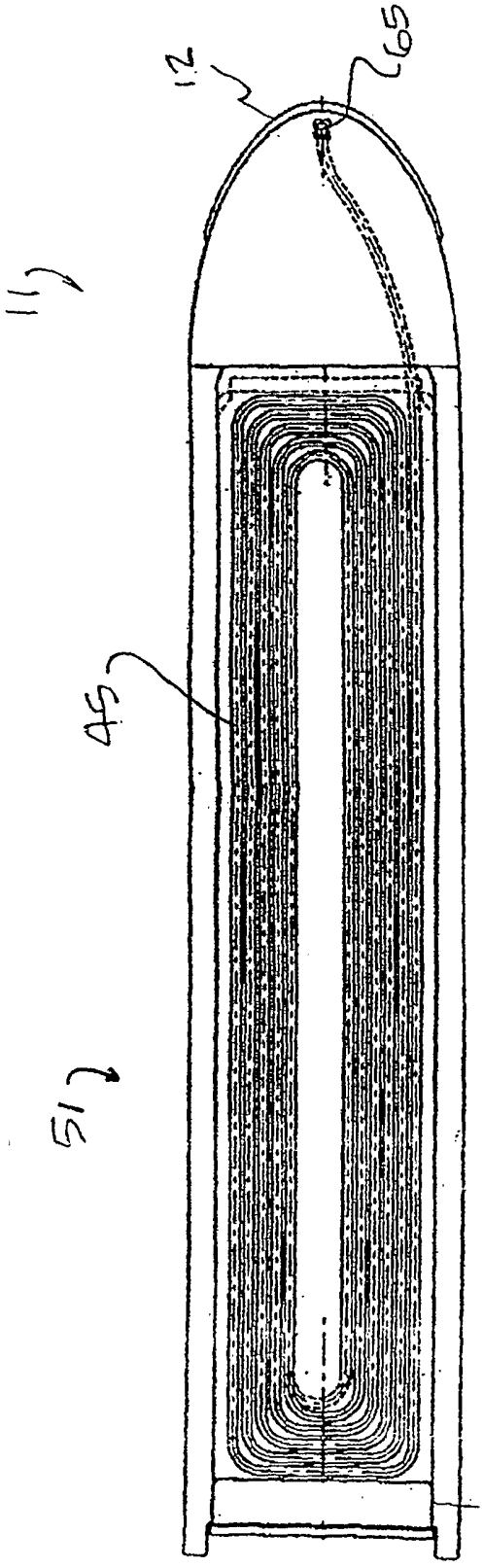


FIG. 3

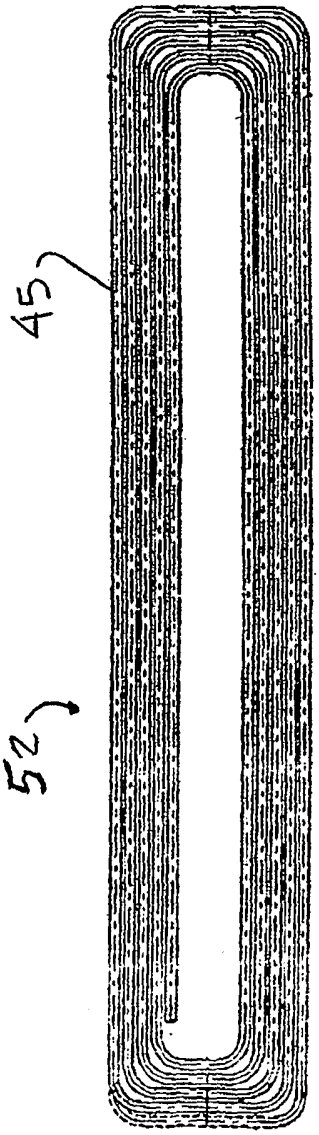


FIG. 4

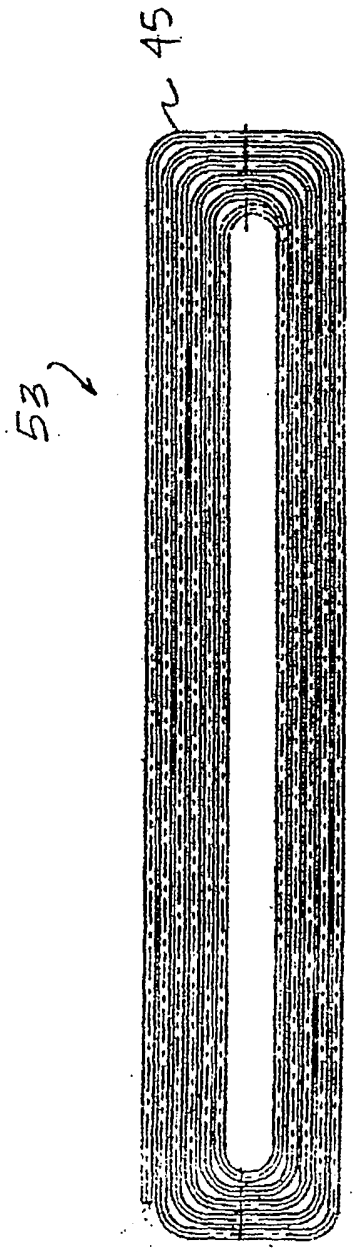

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FIG. 5

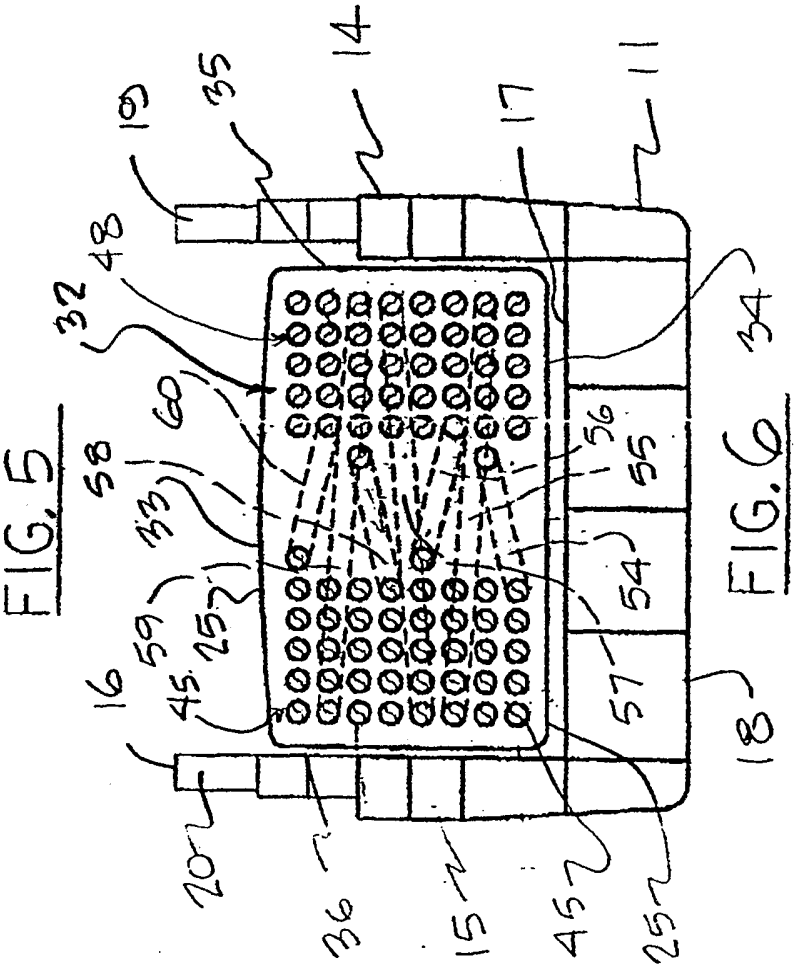

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FIG. 6

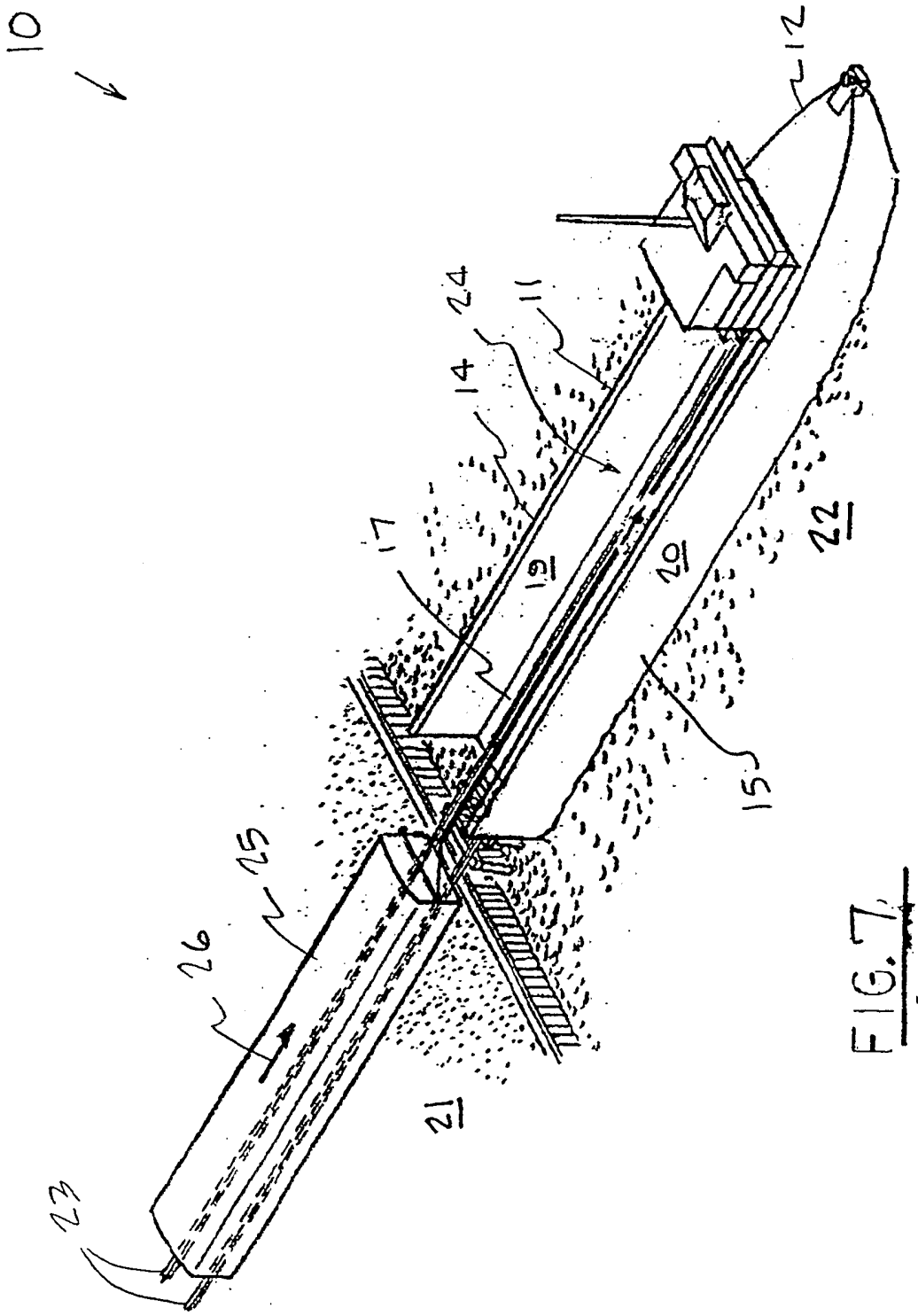


FIG. 7

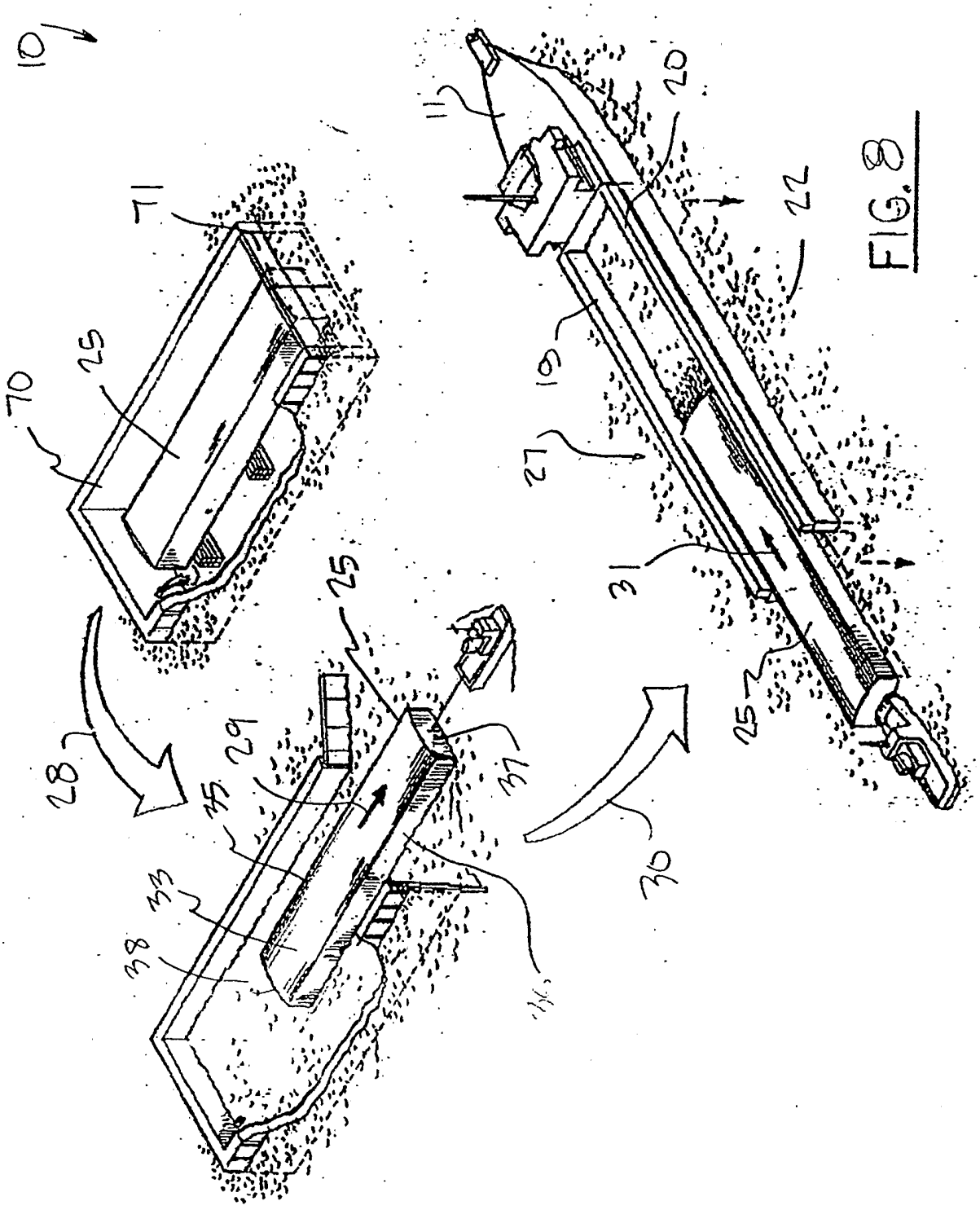


FIG. 8

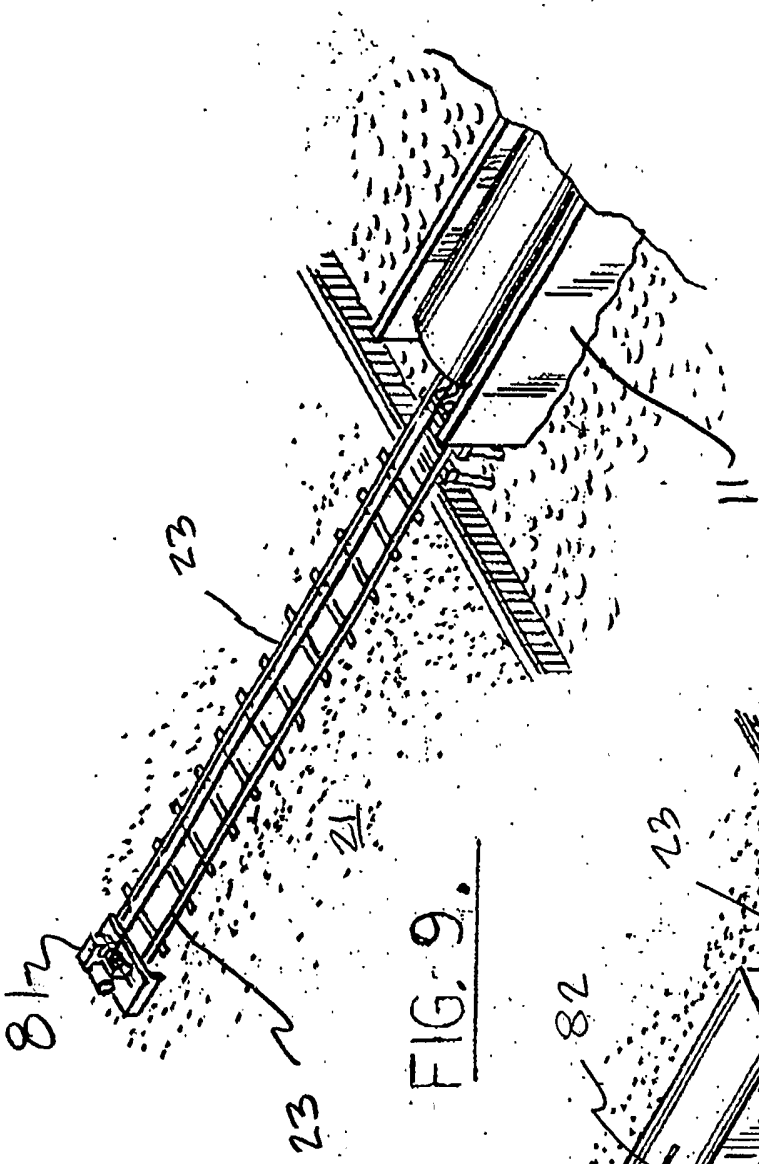


FIG. 9.

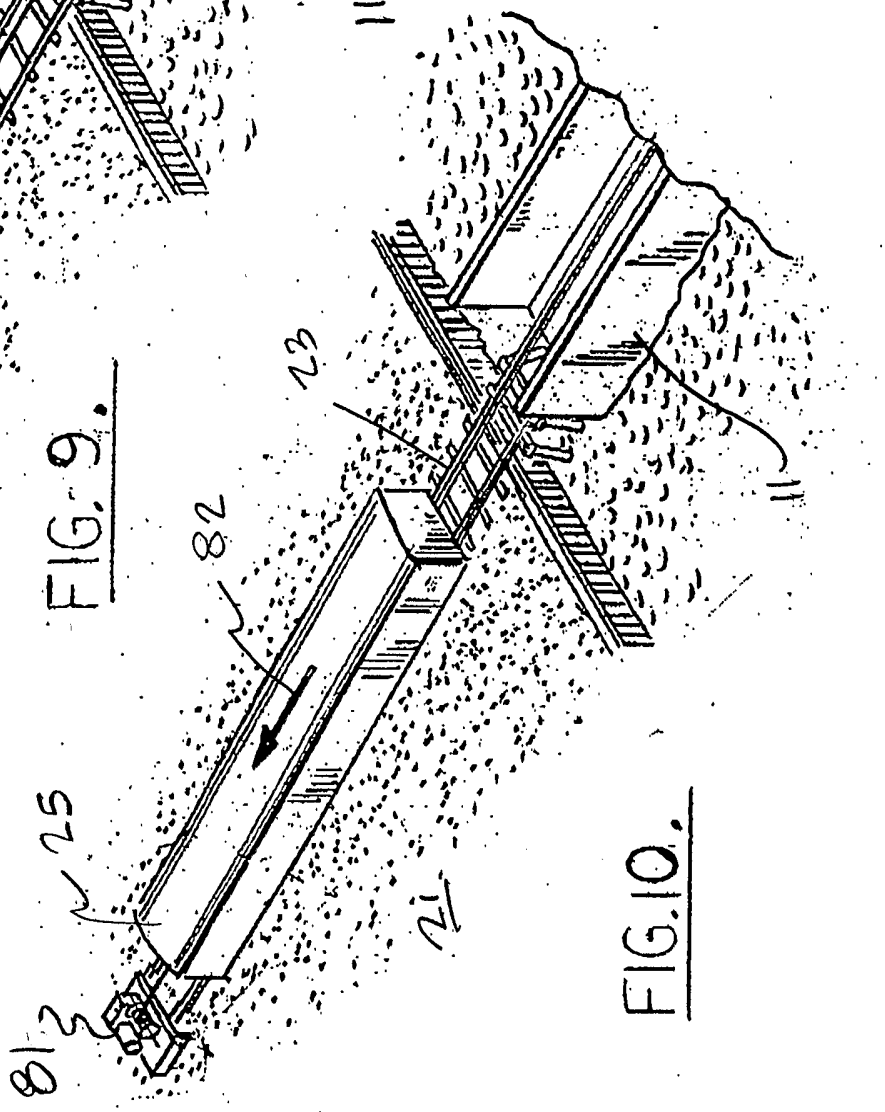


FIG. 10.

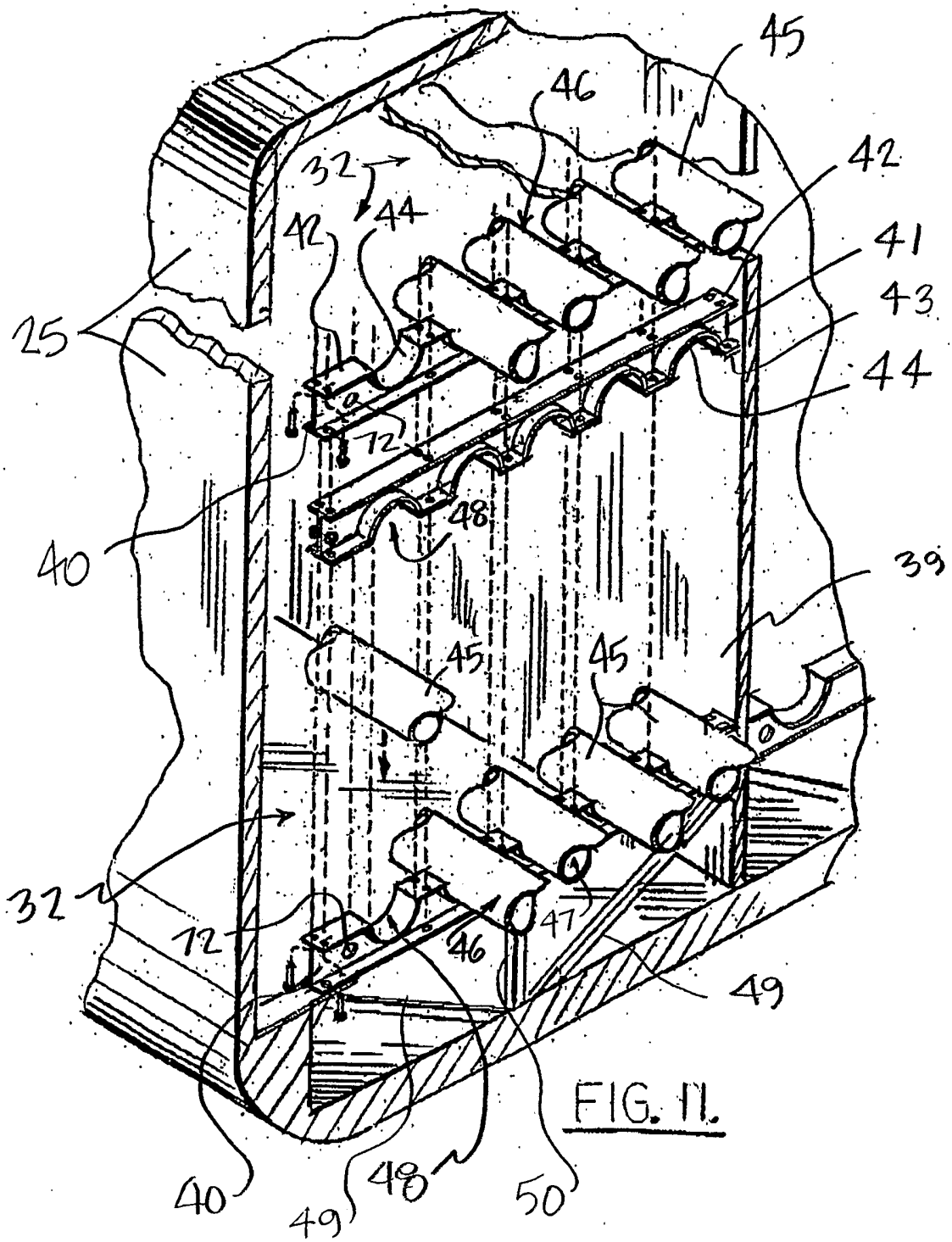

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FIG. 11.

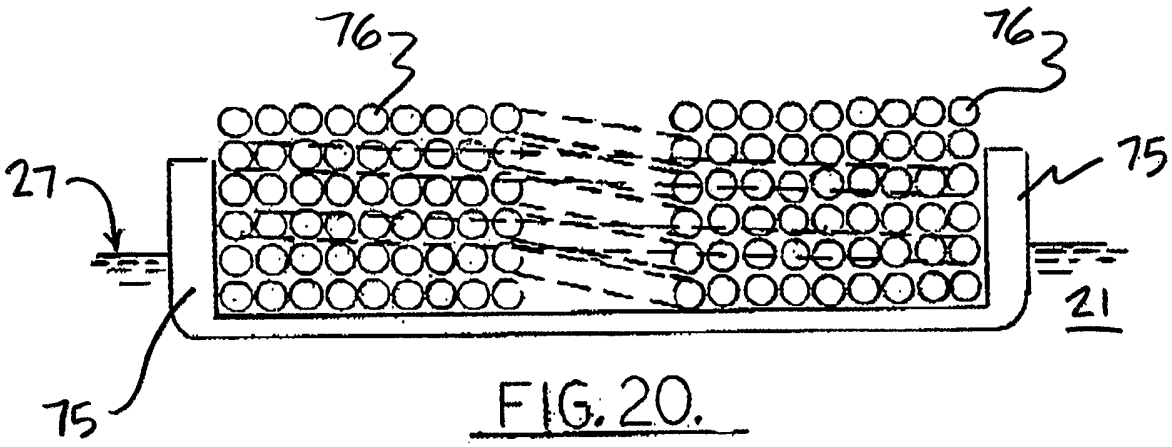


FIG. 20.

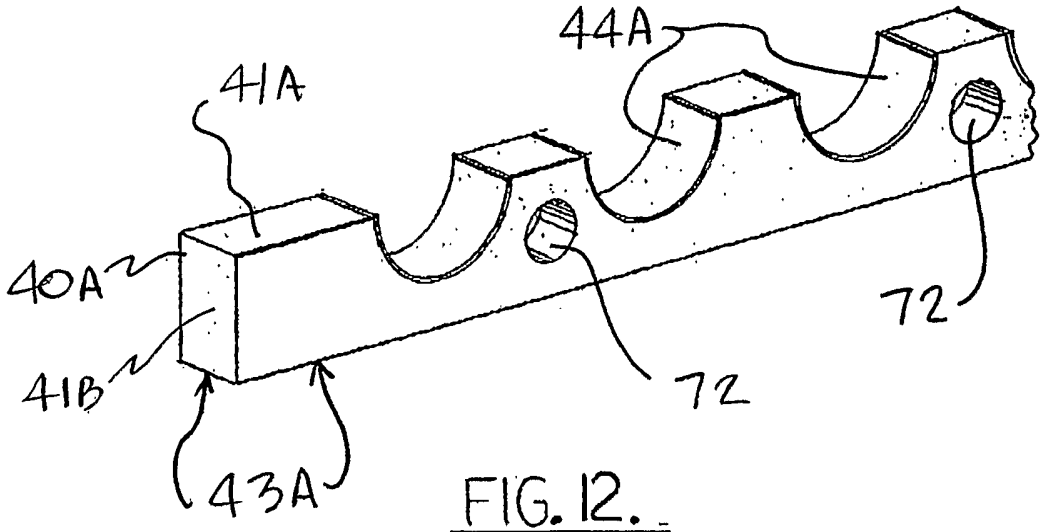


FIG. 12.

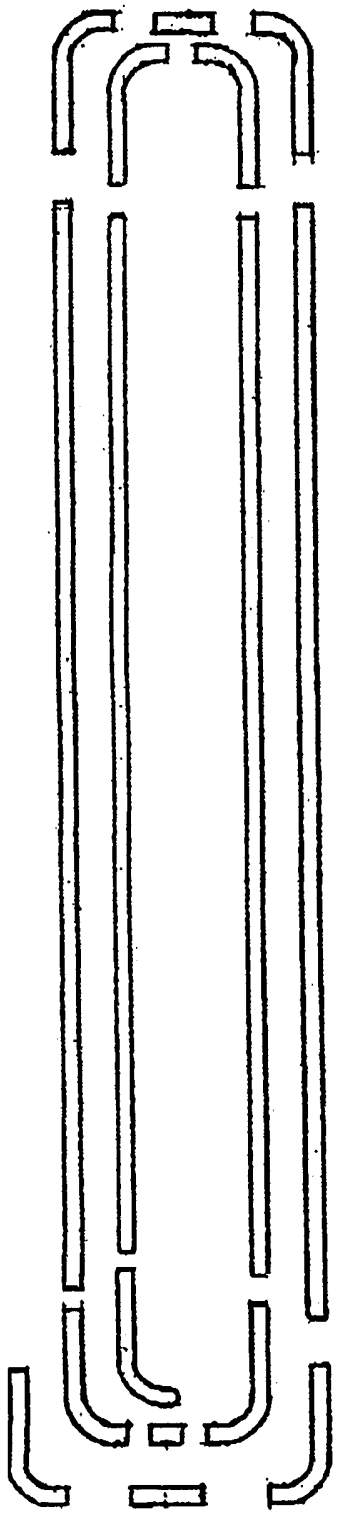


FIG. 13.

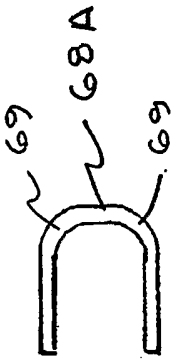


FIG. 14A.

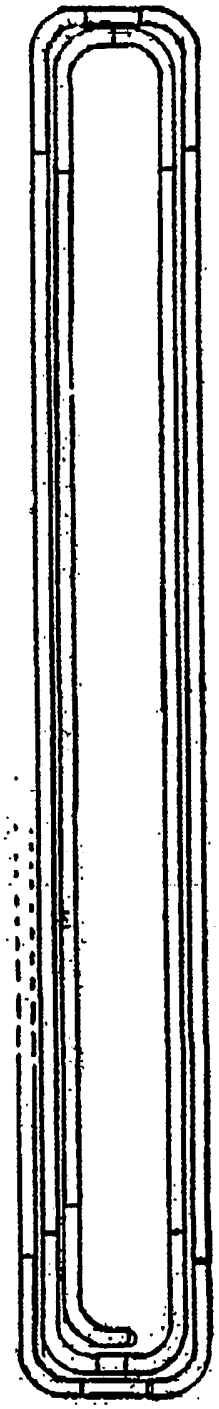


FIG. 14.

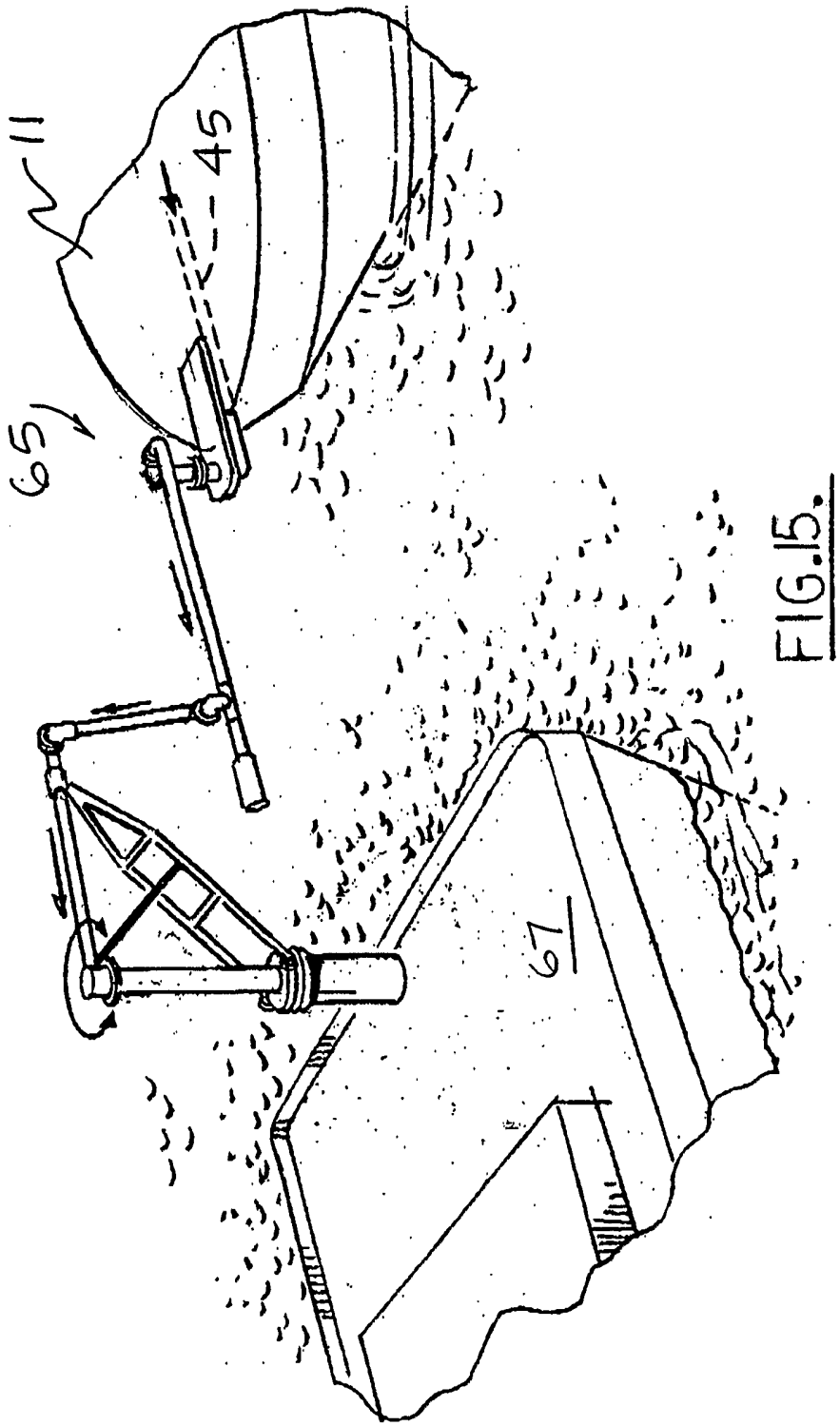


FIG.15.

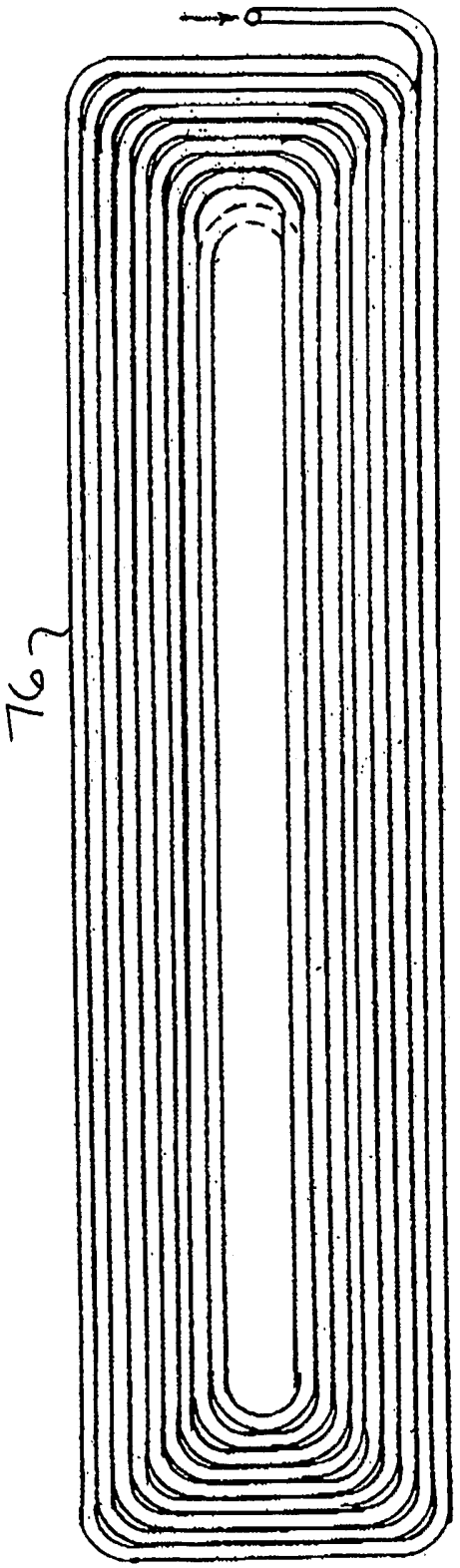


FIG. 16.

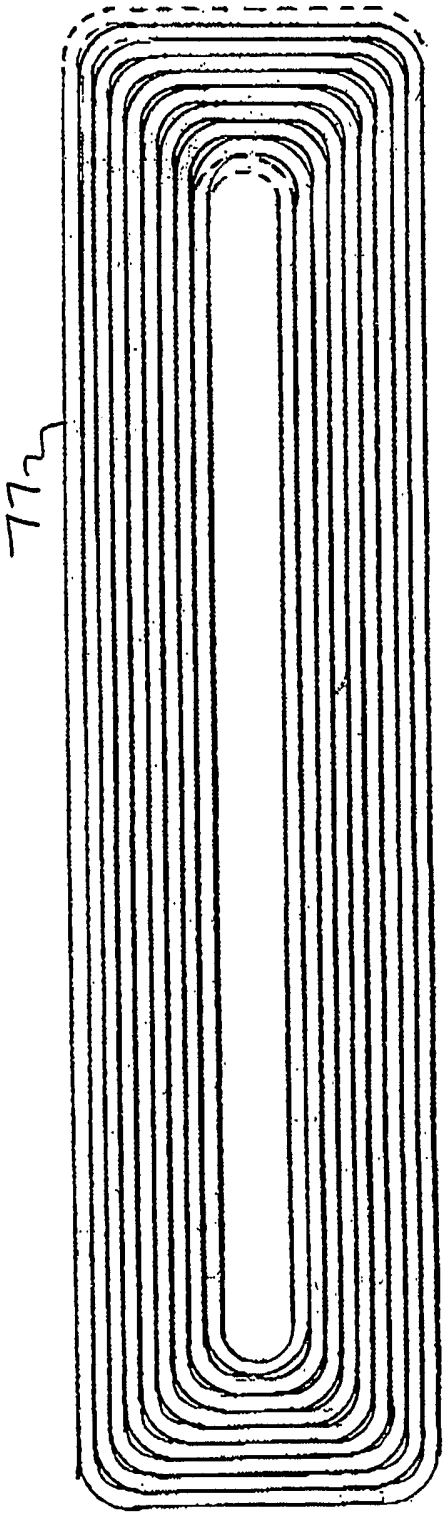


FIG. 17.

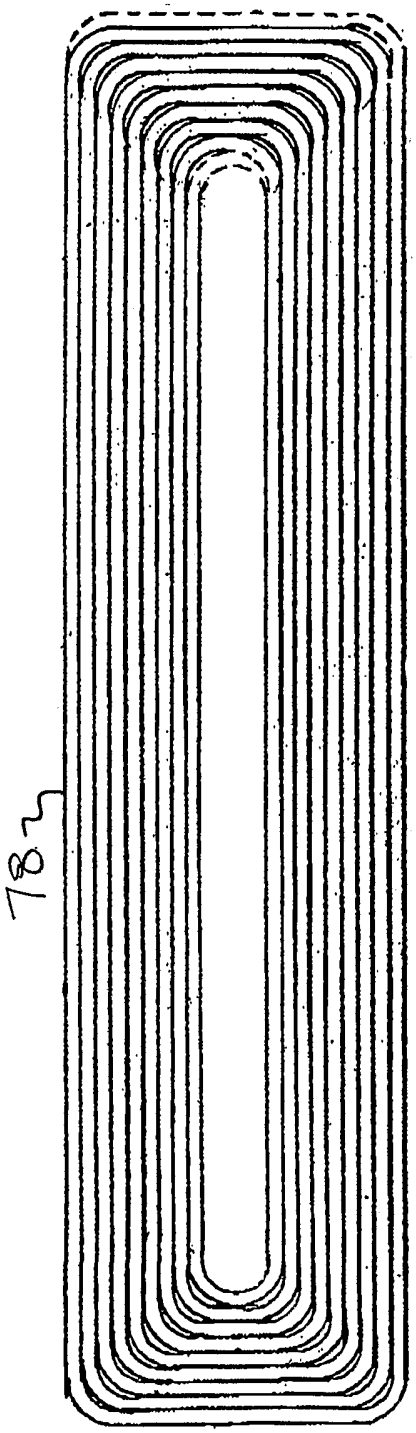


FIG. 18.

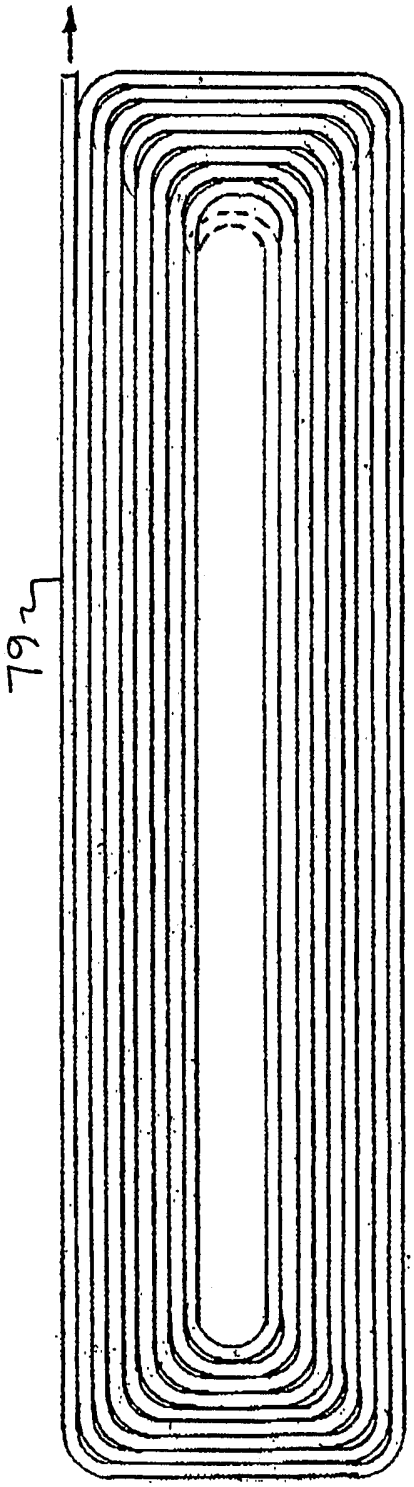


FIG. 19.