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CRYOGENIC TANK

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FIG. 1

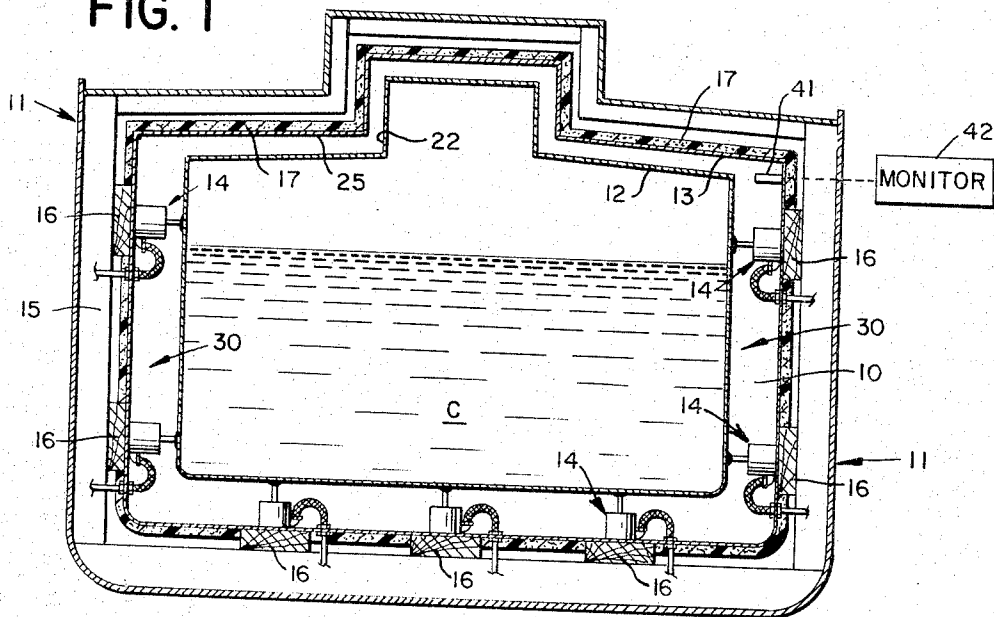
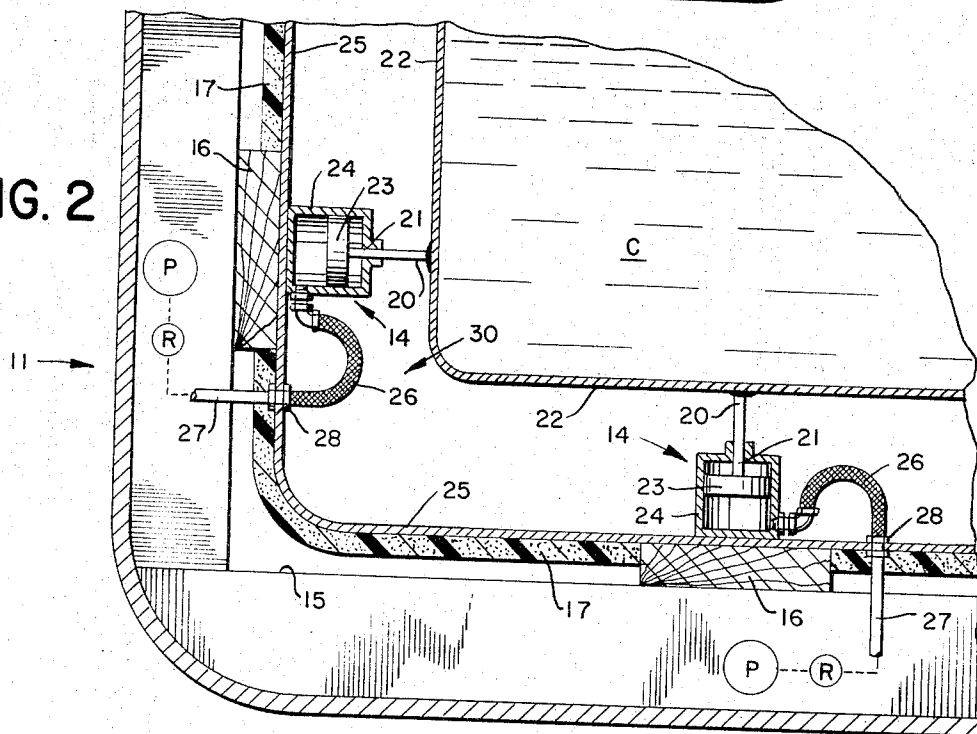


FIG. 2



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CRYOGENIC TANK

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ABSTRACT OF THE DISCLOSURE

The disclosure of the present invention is directed towards a tanker containing an inner cargo tank which is displaceably supported within a similarly shaped larger outer tank. The said outer tank is in turn supported by the tanker structure. The inner tank is supported from the outer tank by a plurality of controllably fluid actuator mechanisms. In addition, the void area between the inner and outer tanks is maintained at a vacuum and includes a leak detection system for indicating a seepage of cargo gases from the inner tank into the space between the tanks.

The present invention relates to tanks for cargo ships and the like, and more particularly, to improvements in tankers adapted to transport cryogenic cargoes, such as liquefied gases, at atmospheric pressures.

It has been established that the transportation of gases, such as natural gas, hydrogen, oxygen, methane, and the like, to remote locations, may best and most efficiently be accomplished by reducing the volume of the gas through its conversion into the liquid state. Such a conversion enables the storage volume requirements to be greatly reduced (approximately six-hundredfold for a given quantity of methane gas, for example) and, as should be appreciated, enables the most efficient transfer of the gas to a remote area.

In order to transfer liquefied gas in a practical and economical manner in relatively large volumes, it is necessary to store the liquefied gas at approximately atmospheric pressure, since large containers built to withstand superatmospheric pressures would be impractical, if not impossible, to construct for use on seagoing tankers or the like. Moreover, liquefied gases maintained at atmospheric pressures have extremely low vaporization points, ranging from about -435° F. for liquefied hydrogen, to -28° F. for liquefied ammonia, and these unusually low temperatures of the liquids present certain problems in the design and production of insulated cargo containers. Specifically, the containers must be capable of preventing heat losses which would lead to subsequent vaporization of the stored liquefied gas and of withstanding the internal stresses that may be induced therein by the large temperature gradient through the walls of the container. In addition, the ship must be safeguarded against uncontrolled flow of the low temperature liquid into contact with parts of the structure which could be damaged thereby.

Accordingly, for the purposes of safety and reliability and in accordance with accepted regulatory codes, it has been a well-established practice to provide at least two liquid-tight barriers in containers used for the transportation and/or storage of liquefied natural gases at cryogenic temperatures, each of which barriers is possessed of sufficient strength to withstand the hydrostatic loads imposed by the liquefied gas cargo and each of which is capable of withstanding the thermally induced stresses of the supercooled liquefied natural gas cargo. To this end, containers designed for the purpose of storing liquefied gases have often included a metallic inner tank,

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fabricated from a material such as aluminum or stainless steel, which retains its strength and ductility at the extremely low temperatures, and an enveloping insulated chamber in which the tank is supported for limited displacement relative thereto.

In accordance with the principles of the present invention, an inner tank is supported for extensive displacement within a similarly shaped, but larger, outer tank supported by the ship's structure. Specifically, the inner tank is supported by and through the tie rods of a series of fluid actuators arrayed thereabout and associated with the outer tank for three-dimensional movement relative thereto. As an important aspect of the invention, careful regulation of the pressure in the actuators, through a suitable fluid control system allows the inner tank to be maintained in a controllably restrained manner accommodating its controlled displacement in any and all directions relative to the outer tank when subjected to varying thermally induced stresses or when subjected to the dynamic forces encountered at sea. Thus, by providing independent and controllably restraining support of the inner tank, its structure will not be unduly stressed nor will its integrity be impaired when it is subjected to the severe thermodynamic and hydrostatic forces of a cryogenic cargo. Moreover, the supporting outer tank, being independent of the inner tank and effectively separated therefrom by the array of controllably displaceable fluid actuator mechanisms, will be substantially free of extraordinary stresses during the loading and unloading (chilling and warming) cycle of the inner tank. Accordingly, the new and improved, fluid actuator support system substantially reduces the magnitude of the stresses induced and their potential deleterious effects upon both the inner and the outer tank structures.

As another important aspect of the invention, the space between the inner and outer tanks forms a chamber which is utilized for multiple purposes. Specifically, the chamber is evacuated and maintained under a predetermined vacuum by a suitable pumping system to provide predetermined thermal insulation of the inner tank. Additionally, the chamber is connected to and continuously monitored by a detection system which is adapted to detect the presence of cargo gas, which would, of course, be indicative of a leak in the inner tank. The outer tank, itself, is further insulated by an inexpensive insulation material, which need not be liquid tight, inasmuch as the requisite liquid-tight barriers are provided by the inner and outer tanks. Moreover, the thickness of the insulation material required will not be excessive, since the evacuated chamber provides substantial insulation.

For a more complete understanding of the present invention and its attendant advantages, reference should be made to the following detailed description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a fragmentary cross-sectional view of a tanker including a fluid actuator supported inner cargo tank arrangement embodying the principles of the present invention; and

FIG. 2 is an enlarged, fragmentary view of the fluid actuator support means shown in FIG. 1.

Referring to the drawings and initially to FIG. 1 thereof, the new and improved cargo tank system is included in a cargo space 10 of a double hulled tanker 11 of the general type conventionally employed in cryogenic service. Pursuant to the principles of the invention, a closed inner tank 12, of stainless steel, aluminum, or like material of high strength and ductility at extremely low temperatures, is controllably supported within a similar closed outer tank 13 by a plurality of fluid actuator mechanisms 14. The actuator mechanisms extend between the bottom, side and end walls of the respective inner and outer tanks in a manner controllably accommodative of relative dis-

placements therebetween caused by dimensional changes thermally induced in the inner tank or by dynamic rolling and pitching forces acting upon the tanks. The outer tank 13 is in turn supported by the inner hull structure 15 of the ship, through wooden blocks 16 or the like suitably secured in place therebetween.

In accordance with the invention and as shown best in FIG. 2, the inner tank 12 is supported in a spaced relation to the outer tank 13 in a manner providing for three degrees of freedom. Specifically, the distal end 20 of an actuator piston rod 21 is welded or otherwise suitably and rigidly fastened to the external surfaces 22 of the inner tank. The enlarged piston 23 of the actuator is supported within its cylinder 24 for controllable displacement along the axis normal to the wall of the tank, while the cylinder itself is free to slide along the vertical and horizontal planes of the outer tank walls 25. Flexible hoses 26 connect the cylinders 24 to a suitable pressure fluid source P through a pipeline 27. Suitable liquid-tight seals 28 maintain the impermeability of the outer tank 13.

A chamber 30 is defined between the spaced inner and outer tanks 12, 13, which is bridged only by the actuator mechanisms 14. In accordance with the invention, the chamber is partially evacuated through an exhaust system 41 which includes a monitor 42 adapted to detect the presence of cargo gas which would be indicative of a leak in the primary barrier or inner tank (FIG. 1). Evacuation of the chamber 30 provides an effective predetermined thermal insulation of the cargo C in the inner tank, as will be understood.

As a secondary means of insulation, the external surfaces of the outer tank 13 are clad with a suitable layer of thermal insulation 17. The external insulation need not be cargo-impermeable or possess exceptional dimensional stability and strength, as will be understood, since the requisite primary and secondary impermeable cargo barriers are provided by the inner and outer tanks, respectively, and it is not necessary to derive barrier properties from the insulation. In addition, since the evacuated chamber provides a significant measure of thermal insulation, the thermal insulating requirements of the external insulation are modest. Therefore, a relatively inexpensive insulation system, advantageously of a sprayed-on type, (sprayed-on urethane foam) may be employed, in comparison with systems in which the insulation, itself, functions as a cargo barrier.

In the illustrated form of the invention, each of the actuator rods 21 possesses three degrees of freedom relative to the outer tank 13 or, in other words, is "free-floating," since it is bi-directionally movable in the actuator cylinder 24 and since it is movable in horizontal and vertical directions with the entire actuator cylinder, itself, in the general planes of the walls 25 of the outer tank. Moreover, in accordance with a more specific aspect of the invention, the pressure in the cylinders 24 and the forces acting inwardly against the pistons 23 are controlled through a suitable fluid medium, an inert gas such as nitrogen, for example, by one or more external pressure regulators R communicating with the cylinders 24 through the flexible hoses 30, individually or in appropriate groups. The external control of the actuators enables the inner tank to be optimally stabilized within the ship structure and to be free from the effects of rolling or pitching to which the ship may be subjected in a rough sea.

It should be appreciated that by utilizing the new and improved "free-floating," dynamic support system hereinabove described, the inner tank will be able to expand and contract controllably relative to the outer tank without inducing deleterious stresses in either. Moreover, through the use of an intermediate evacuated chamber,

the cost of the insulation system may be reduced to a significant degree, and, through the careful regulation of the pressure in the cylinders, increased stabilization of the inner tank may be achieved.

It should be understood that the specific form of the invention herein illustrated and described is intended to be representative only, as certain changes may be made therein without departing from the clear teachings of the disclosure. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

What is claimed is:

1. In a tanker having a hull, a tank for storing and transporting liquefied gases at cryogenic temperatures and atmospheric pressure comprising
 - (a) an inner impermeable tank of a material retaining its ductility at cryogenic temperatures,
 - (b) an outer impermeable tank of a material retaining its ductility at cryogenic temperatures,
 - (c) means mounting said inner tank in said outer tank for effectively free and independent movement relative thereto, said means comprising fluid actuator means arrayed about said outer tank for limited displacement relative thereto along predetermined axes, actuator piston rods projecting from said actuator means and controllably displaceable along predetermined axes perpendicular to the planes of said last mentioned axes, said rods connected at their distal ends to said inner tank,
 - (d) said inner and outer tanks defining a chamber therebetween,
 - (e) means for evacuating the air in said chamber and for maintaining a vacuum therein,
 - (f) gas detection means associated with said chamber and adapted to detect the presence of gas therein, and
 - (g) thermal insulation means covering said outer tank, and
 - (h) insulating bearing means interposed between said outer tank and the interior of said hull whereby said hull supports said outer tank.
2. The cargo tank of claim 1, which includes
 - (a) fluid control means associated with said fluid actuator means,
 - (b) said control means being adapted to regulate the pressure in said actuator means to accommodate expansion and contraction of said inner tank relative to said outer tank.
3. The cargo tank of claim 1, in which
 - (a) said thermal insulation means includes sprayed-on insulation material.

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