SUMMARY OF THE INVENTION

[0007] The invention relates particularly to the marine gas transportation of non-liquefied compressed natural gas although it could be used to transport other gases. It is an object of the present invention to reduce the cost of ships or barges designed to carry compressed gases, such as CNG.

[0007a] According to a first aspect, there is provided an assembly for transporting fluid comprising: a cargo hold in a barge or ship, said cargo hold including a lower support and a side support on each side of the lower support; and a plurality of pipes for fluid containment, each pipe of the plurality of pipes having at least one end that is open, the plurality of pipes being supported on the lower support between the side supports; and the plurality of pipes is stacked in a hexagonal manner; and an upper forcing member that is configured to forcefully bear down on the plurality of pipes via a forcing mechanism to apply sufficient compressive force to the plurality of pipes stacked in the cargo hold so that friction between the pipes will prevent any significant relative movement of the pipes caused by motions of the barge or ship, or by flexing of the barge or ship, or by strains caused by differential temperature or pressure; and a fluid line system connected to the open ends of the plurality of pipes for filling and unloading fluid to the pipes; and wherein the plurality of pipes for fluid containment are surrounded by a plurality of empty pipes of substantially the same outer diameter as the fluid containment pipes.

[0007b] According to a second aspect, there is provided a method of transporting fluid in pipes comprising the steps of: hexagonally stacking pipes on or in a vessel in a lengthwise configuration; forcing said pipes together so strongly with a hold down beam that any motion of the vessel, including

flexing of the vessel itself, does not induce relative motion between the pipes themselves or between the pipes and the vessel, wherein the plurality of pipes contributes to the strength of the vessel and so said pipes and vessel move together as though they were one.

[0007c] According to a third aspect, there is provided a fluid transport assembly comprising: a lower support having a first side and a second side; a first side support affixed to said first side of said lower support, said first side support approximately perpendicular to said lower support; a second side support affixed to said second side of said lower support, said second side support approximately perpendicular to said lower support; wherein said first side support, said lower support and said second side support define a pipe receiving area; a plurality of pipes stacked in a hexagonal pattern on said lower support, between said side supports, in said pipe receiving area; a top support above said pipe receiving area; a forcing member adjacent one of said first side support, said second side support and said top support, said forcing member for forcefully applying pressure to said plurality of pipes for applying compressive force to said plurality of pipes for increasing static friction between adjacent ones of said plurality of pipes and between ones of said plurality of pipes and adjacent structure selected from said lower support, said first side support, said second side support and said top support; stress spreading structure comprising a layer of empty pipe between said forcing member and said plurality of pipes for spreading concentrated stresses generated by compression forces exerted by said forcing member.

[0007d] According to a fourth aspect, there is provided a fluid transport assembly comprising: a ship having a hull, a forward cargo bulkhead, an aft cargo bulkhead, a centerline longitudinal bulkhead for dividing said hull into a starboard cargo hold and a port cargo hold; a plurality of bottom support members incorporated in a bottom of said hull; a plurality of side support members comprising starboard hull side support members, starboard centerline side support members, port hull side support members, port centerline side support members; wherein said plurality of side support members and said plurality of bottom support members are equally spaced and aligned with one another along a

length of said hull; a plurality of pipes in said starboard cargo hold, said plurality of pipes extending from proximate said forward cargo bulkhead to proximate said aft cargo bulkhead, said plurality of pipe stacked in a hexagonal pattern, said plurality of pipe defining an outer layer of pipe and an interior grouping of pipe; a plurality of pipes in said port cargo hold, said plurality of pipes having a first end proximate said forward cargo bulkhead, said plurality of pipes having a second end proximate said aft cargo bulkhead, said plurality of pipe stacked in a hexagonal pattern, said plurality of pipe defining a an outer layer of pipe and an interior grouping of pipe; a fixed top support member above said plurality of pipes in said starboard cargo hold and above said plurality of pipes in said port cargo hold; a forcing beam adjacent to an upper portion of said plurality of pipes; a plurality of top forcing mechanisms in between said top support member and said forcing beam, each of said plurality of top forcing mechanisms aligned with one of said plurality of side support members, wherein said top forcing mechanisms are provided with bracing arms for preventing longitudinal loads from pushing said forcing beam out of alignment, wherein the bracing arms are affixed at a first end to said forcing beam and at a second end to said forcing mechanism; wherein said outer layer of pipe for remaining empty and for distributing loads generated by said forcing mechanism; a manifold system adjacent at least one of said first end and said second end of said plurality of pipes for filling and emptying said pipe.

[0007e] According to a fifth aspect, there is provided a fluid transport assembly comprising: a plurality of bottom support members; a plurality of side support members; wherein said plurality of side support members and said plurality of bottom support members are equally spaced and aligned with one another along a length of the assembly, said side support members and said bottom support members defining a pipe receiving area; a plurality of pipes in said pipe receiving area, said plurality of pipe stacked in a hexagonal pattern, said plurality of pipe defining an outer layer of pipe and an interior grouping of pipe, said plurality of pipes having a first end and a second end; a top fixed support member above said plurality of pipes in said pipe receiving area and above said plurality of pipes; a forcing beam adjacent to an upper portion of said plurality of pipes; a plurality of top forcing

mechanisms in between said top support member and said forcing beam, each of said plurality of top forcing mechanisms aligned with one of said plurality side support members, wherein said top forcing mechanisms are provided with bracing arms for preventing longitudinal loads from pushing said forcing beam out of alignment, wherein the bracing arms are affixed at a first end to said forcing beam and at a second end to said forcing mechanism; wherein said outer layer of pipe for remaining empty and for distributing loads generated by said forcing mechanism; a manifold system adjacent at least one of said first end and said second end of said plurality of pipes for filling and emptying said pipe.

[0008] A gas storage system particularly adapted for the transportation of large quantities of compressed gases, such as CNG, in or on a ship or a barge, primarily by means of long, straight hexagonally stacked lengths of pipe that are so strongly forced together that they cannot move relative to each other or to the ship and are connected by a manifold. Hereinafter the description will focus on a ship application to carry CNG below the top deck but it is obvious to one skilled in the art that this invention could also be employed on the top deck of the ship or on the top deck of a barge or below the top deck of a barge. It is also obvious to one skilled in the art that this invention could also be employed to carry compressed gases other than CNG.

[0009] The pipe runs the almost the entire length of the ship in continuous straight lengths and is hexagonally packed and firmly pressed together by a forcing mechanism. As described in Canadian patent number 2,283,008 the ship can be designed so that the holds of ship can be the entire length of the ship with the watertight transverse bulkheads being accommodated by filling the gaps between the hexagonally stacked pipes with a watertight material at the required intervals. The pipe diameter can be of any reasonable dimension, e.g., from approximately 8 inches to approximately 36 inches or other diameters. The precise diameter and length of pipe will depend on the economics of the system taking into account the cost of the various

CLAIMS

What is claimed is:

1. An assembly for transporting fluid comprising:

a. a cargo hold in a barge or ship, said cargo hold including a lower support and a side support on each side of the lower support; and

b. a plurality of pipes for fluid containment, each pipe of the plurality of pipes having at least one end that is open, the plurality of pipes being supported on the lower support between the side supports; and

c. the plurality of pipes is stacked in a hexagonal manner; and

d. an upper forcing member that is configured to forcefully bear down on the plurality of pipes via a forcing mechanism to apply sufficient compressive force to the plurality of pipes stacked in the cargo hold so that friction between the pipes will prevent any significant relative movement of the pipes caused by motions of the barge or ship, or by flexing of the barge or ship, or by strains caused by differential temperature or pressure; and

e. a fluid line system connected to the open ends of the plurality of pipes for filling and unloading fluid to the pipes; and

f. where the plurality of pipes for fluid containment are surrounded by a plurality of empty pipes of substantially the same outer diameter as the fluid containment pipes.

2. The assembly of claim 1 wherein said plurality of pipes are oriented lengthwise within said barge or ship.

3. The assembly of claim 1 wherein said lower support comprises a plurality of bottom support members incorporated in a bottom of a hull of said barge or ship.

4. The assembly of claim 1 where the pipes are made from steel.

5. The assembly of claim 1 where the forcing mechanism is a plurality of jacks between the upper holding member and a top fixed deck of the hold, said plurality of jacks are spaced over a length of said upper forcing member.

6. The assembly of claim 1 wherein a friction element is placed between the pipes.

7. The assembly of claim 6 wherein said friction element is a roughened area of the pipe for maximizing friction between the pipes.

8. The assembly of claim 1 where space in the cargo hold is filled with an inert gas.

9. The assembly of claim 1 wherein the forcing mechanism includes a tightening mechanism to permit pressing the upper forcing member down over the plurality of pipes after the first force is applied to accommodate settling in the plurality of pipes.

10. A method of transporting fluid in pipes comprising the steps of: hexagonally stacking pipes on or in a vessel in a lengthwise configuration; forcing said pipes together so strongly with a hold down beam that any motion of the vessel, including flexing of the vessel itself, does not induce relative motion between the pipes themselves or between the pipes and the vessel, wherein the plurality of pipes contributes to the strength of the vessel and so said pipes and said vessel move together as though they were one.

11. The method of claim 10 further comprising: locating a layer of empty pipe between said hold down beam and said pipes.

12. The method of claim 10 wherein: said step of stacking comprises locating said pipes in a cargo hold; said step of forcing comprises extending a plurality of jacks between the hold down beam and a top fixed deck of the hold, said plurality of jacks are spaced over length of said hold down beam.

13. The method of claim 10 wherein said vessel comprises a lower support comprising a plurality of bottom support members incorporated in a bottom of a hull of said vessel.

14. The method of claim 10 where the vessel is a barge.

15. The method of claim 10 where the vessel is a ship.

16. The method in claim 10 where the pipes act as pressure vessels.

17. The method on claim 10 where the pipes carry compressed gases such as compressed natural gas.

18. A fluid transport assembly comprising:

a lower support having a first side and a second side;

a first side support affixed to said first side of said lower support, said first side support approximately perpendicular to said lower support;

a second side support affixed to said second side of said lower support, said second side support approximately perpendicular to said lower support;

wherein said first side support, said lower support and said second side support define a pipe receiving area;

a plurality of pipes stacked in a hexagonal pattern on said lower support, between said side supports, in said pipe receiving area;

a top support above said pipe receiving area;

a forcing member adjacent one of said first side support, said second side support and said top support, said forcing member for forcefully applying pressure to said plurality of pipes for applying compressive force to said plurality of pipes for increasing static friction between adjacent ones of said plurality of pipes and between ones of said plurality of pipes and adjacent structure selected from said lower support, said first side support, said second side support and said top support;

stress spreading structure comprising a layer of empty pipe between said forcing member and said plurality of pipes for spreading concentrated stresses generated by compression forces exerted by said forcing member.

19. The fluid transport assembly according to claim 18 further comprising: a forced mechanism between the forcing member and said top support of the pipe receiving area, said forcing mechanism comprising a plurality of jacks spaced over a length of said forcing member.

20. The fluid transport assembly according to claim 18 wherein: said pipe receiving area is in or on a barge or ship; said plurality of pipes are oriented lengthwise within said barge or ship.

21. The fluid transport assembly according to claim 18 wherein: said pipe receiving are is in or on a barge or ship; said lower support comprises a plurality of bottom support members incorporated in a bottom of a hull of said barge or ship.

22. The fluid transport assembly according to claim 18 further comprising:

A forced mechanism for acting on said forcing member wherein said forcing mechanism applies a force in a force direction; and bracing structure for providing restraint in a direction perpendicular to said force direction.

23. The fluid transport assembly according to claim 18 wherein said stress spreading structure further comprises a layer of empty pipe surrounding said plurality of pipes.

24. The fluid transport assembly according to claim 18 further comprising a means for connecting each one of said plurality of pipes to a filling or emptying mechanism.

25. The fluid transport assembly according to claim 24 wherein said filling or emptying mechanism is a manifold system.

26. A fluid transport assembly comprising:

a ship having a hull, a forward cargo bulkhead, an aft cargo bulkhead, a centerline longitudinal bulkhead for dividing said hull into a starboard cargo hold and a port cargo hold;

a plurality of bottom support members incorporated in a bottom of said hull;

a plurality of side support members comprising starboard hull side support members, starboard centerline side support members, port hull side support members, port centerline side support members;

wherein said plurality of side support members and said plurality of bottom support members are equally spaced and aligned with one another along a length of said hull;

a plurality of pipes in said starboard cargo hold, said plurality of pipes extending

from proximate said forward cargo bulkhead to proximate said aft cargo bulkhead, said plurality of pipe stacked in a hexagonal pattern, said plurality of pipe defining an outer layer of pipe and an interior grouping of pipe;

a plurality of pipes in said port cargo hold, said plurality of pipes having a first end proximate said forward cargo bulkhead, said plurality of pipes having a second end proximate said aft cargo bulkhead, said plurality of pipe stacked in a hexagonal pattern, said plurality of pipe defining a an outer layer of pipe and an interior grouping of pipe;

a fixed top support member above said plurality of pipes in said starboard cargo hold and above said plurality of pipes in said port cargo hold;

a forcing beam adjacent to an upper portion of said plurality of pipes;

a plurality of top forcing mechanisms in between said top support member and said forcing beam, each of said plurality of top forcing mechanisms aligned with one of said plurality of side support members, wherein said top forcing mechanisms are provided with bracing arms for preventing longitudinal loads from pushing said forcing beam out of alignment, wherein the bracing arms are affixed at a first end to said forcing beam and at a second end to said forcing mechanism;

wherein said outer layer of pipe for remaining empty and for distributing loads generated by said forcing mechanism;

a manifold system adjacent at least one of said first end and said second end of said plurality of pipes for filling and emptying said pipe.

27. The fluid transport assembly according to claim 26 wherein: said plurality of pipes are

oriented lengthwise within said hull of said ship.

28. The fluid transport assembly according to claim 26 wherein: the forcing mechanism is a plurality of jacks between the forcing beam and the top support member, said plurality of jacks are spaced over a length of said forcing beam.

29. A fluid transport assembly comprising:

a plurality of bottom support members;

a plurality of side support members;

wherein said plurality of side support members and said plurality of bottom support members are equally spaced and aligned with one another along a length of the assembly, said side support members and said bottom support members defining a pipe receiving area;

a plurality of pipes in said pipe receiving area, said plurality of pipe stacked in a hexagonal pattern, said plurality of pipe defining an outer layer of pipe and an interior grouping of pipe, said plurality of pipes having a first end and a second end;

a top fixed support member above said plurality of pipes in said pipe receiving area and above said plurality of pipes;

a forcing beam adjacent to an upper portion of said plurality of pipes;

a plurality of top forcing mechanisms in between said top support member and said forcing beam, each of said plurality of top forcing mechanisms aligned with one of

said plurality side support members, wherein said top forcing mechanisms are provided with bracing arms for preventing longitudinal loads from pushing said forcing beam out of alignment, wherein the bracing arms are affixed at a first end to said forcing beam and at a second end to said forcing mechanism;

wherein said outer layer of pipe for remaining empty and for distributing loads generated by said forcing mechanism;

a manifold system adjacent at least one of said first end and said second end of said plurality of pipes for filling and emptying said pipe.

30. The fluid transport assembly according to claim 29 wherein said pipe receiving area is on or in a vessel having a hull; and wherein said plurality of bottom support members are incorporated in a bottom of said hull.

31. The fluid transport assembly according to claim 29 wherein said pipe receiving area is on or in a vessel; and wherein said plurality of pipes are oriented lengthwise in said vessel.

32. The fluid transport assembly according to claim 29 wherein the forcing mechanism is a plurality of jacks between the forcing beam and the top fixed support member of the pipe receiving area, said plurality of jacks are spaced over length of said forcing beam.

33. The fluid transport assembly according to claim 29 wherein the assembly is located

within a hull of a vessel.

34. The fluid transport assembly according to claim 29 wherein the assembly is located on a deck of a vessel.