strains caused by differential temperature or pressure; and a fluid line system connected to said plurality of pipes for filling and unloading fluid to the pipes.

According to another aspect, the present disclosure refers to a method of transporting gas in a plurality of stacked pipes carried on or in a vessel comprising the steps of: locating a plurality of pipes in a cargo hold of a vessel, wherein said plurality of pipes is stacked in multiple rows, wherein adjacent pipes have two points of contact with the pipes in adjacent rows and wherein adjacent pipes in a same row are separated from one another by a space; maintaining a space between adjacent pipes in a same row of said plurality of stacked pipes; forcing the pipes together so strongly 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.

According to another aspect, the present disclosure refers to a fluid transport assembly comprising: a lower support having a first side and a second side; a first side support adjacent to said first side of said lower support; a second side support adjacent to said second side of said lower support; wherein said first side support, said lower support and said second side support define a pipe receiving area; a row of spacers adjacent said lower support; a plurality of pipes stacked in multiple rows between said first side support and said second side support in said pipe receiving area, said plurality of pipes defining an upper side, a lower side, a first side and a second side, said lower side supported by said row of spacers; a top support above said pipe receiving area; wherein said adjacent pipes in said plurality of pipes having two points of contact between adjacent rows and where adjacent pipes in the same row are separated from one another by a space; a forcing member adjacent one of said sides of said plurality of pipes, 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.

According to another aspect, the present disclosure refers to an assembly for transporting fluid comprising: a cargo hold on or in a transport vessel, said cargo hold including a lower support having a first side and a second side, a first side support on said first side of said lower support, and a second side support on said second side of said lower support; a plurality of pipes for fluid containment received in said cargo hold wherein said

plurality of pipes is stacked in multiple rows, wherein adjacent pipes of said plurality of pipes have two points of contact between adjacent rows of said multiple rows and wherein adjacent pipes in a same row are separated from one another by a space; a forcing member above said plurality of pipes; a forcing mechanism for applying a compressive force to said plurality of pipes via said forcing member, said compressive force being sufficient so that friction between pipes of said plurality of pipes prevents any significant relative movement of pipes of said plurality of pipes; a load equalizer below said forcing member, said load equalizer engaging said forcing member and at least two pipes of said plurality of pipes for distributing said compressive force to said at least two pipes of said plurality of pipes; a fluid line system connected to said pipes of said plurality of pipes for filling and unloading fluid to the pipes.

According to another aspect, the present disclosure refers to a method of transporting gas in a plurality of stacked pipes carried on or in a vessel comprising the steps of: locating the plurality of stacked pipes in a cargo hold of the vessel wherein said plurality of stacked pipes is stacked in multiple rows; maintaining a space between adjacent pipes in a same row of said plurality of stacked pipes; placing a load equalizer above said plurality of stacked pipes; forcing said pipes of said plurality of stacked pipes together so strongly that any motion of the vessel, including flexing of the vessel itself, substantially eliminating relative motion between said pipes of said plurality of said stacked pipes, or between said pipes, and the vessel.

The present disclosure 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 objective of the present disclosure to reduce the cost of ships or barges designed to carry compressed gases, such as CNG.

The present disclosure relates to 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. The lengths of pipe are connected by a manifold. In one example, i.e., a ship application, CNG is carried below the top deck. However, the invention could also be employed on the top deck of a ship or on the top deck of a barge or below the top deck of a barge. The invention could also be employed to carry compressed gases other than CNG.

The pipe runs 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

CLAIMS

What is claimed is:

1. An assembly for transporting fluid comprising:

a cargo hold in or on a transport vessel, said cargo hold including a lower support, a first side support on a first side of the lower support, and a second side support on a second side of said lower support;

a plurality of pipes for fluid containment received in said cargo hold, wherein said plurality of pipes is stacked in multiple rows, wherein adjacent pipes have two points of contact between adjacent rows and wherein adjacent pipes in a same row are separated from one another by a space;

a forcing member above said plurality of pipes;

a forcing mechanism for applying a sufficient compressive force to said plurality of pipes with said forcing member so that friction between the pipes will prevent any significant relative movement of the pipes caused by motions of the transport vessel, or by flexing of the transport vessel, or by strains caused by differential temperature or pressure; and

a fluid line system connected to said plurality of pipes for filling and unloading fluid to the pipes.

2. The assembly of claim 1 further comprising:

a plurality of spacers adjacent said lower support for supporting said plurality of pipes, said spacers for creating said gap between adjacent ones of said pipe in a same row of said plurality of pipes.

3. The assembly of claim 2 wherein:

said plurality of spacers are a plurality of arches adjacent said lower support for supporting said plurality of pipes, said arches oriented convex side up, said arches for creating said gap between adjacent ones of said pipe in said plurality of pipes.

4. The assembly of claim 3 wherein said arches are split pipes that are 1/3 segments of pipe of a same size as pipe in said plurality of pipes.

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

6. The assembly of claim 1 where the fluid containment pipes are surrounded by a plurality of empty pipes or half pipes of substantially the same outer diameter of the fluid containment pipes.

7. The assembly of claim 1 where the forcing mechanism is a plurality of jacks between the hold down beam and the top fixed deck of the hold.

8. The assembly of claim 1 wherein a friction element is placed between the pipes. This friction element could be a roughening of the pipe surface or otherwise preparing the pipe surface to maximize friction between the pipes.

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

10. 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.

11. The assembly of claim 1 wherein:

a load equalizer below said forcing member, said load equalizer engaging said forcing member and at least two pipes of said plurality of pipes for distributing said compressive force to said at least two pipes of said plurality of pipes.

12. The assembly of claim 11 wherein:

said load equalizer is a pressure wedge having a force member engaging side, a first pipe engaging side, and a second pipe engaging side.

13. The assembly of claim 11 wherein said load equalizer is a flowable material.

14. The assembly of claim 13 wherein said flowable material is a concrete grout solution.

15. A method of transporting gas in a plurality of stacked pipes carried on or in a vessel comprising the steps of:

locating a plurality of pipes in a cargo hold of a vessel, wherein said plurality of pipes is stacked in multiple rows, wherein adjacent pipes have two points of contact with the pipes in adjacent rows and wherein adjacent pipes in a same row are separated from one another by a space;

maintaining a space between adjacent pipes in a same row of said plurality of stacked pipes;

forcing the pipes together so strongly 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.

16. The method according to claim 15 wherein said step of maintaining comprises stacking a bottom row of said plurality of pipes on a plurality of spacers for creating a gap between adjacent ones of said pipe in a same row of said pipe; and

wherein other rows of pipe are stacked in said multiple rows, wherein said adjacent pipes have two points of contact with said pipes in said adjacent rows.

17. The method according to claim 16 wherein said step of stacking said plurality of pipes comprises stacking said plurality of pipes on a plurality of split pipes, said split pipes oriented convex side up.

18. The method according to claim 17 wherein said split pipes are 1/3 segments of pipe of a same size as pipe in said plurality of pipes.

19. The method of claim 15 where the vessel is a barge.

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

21. The method of claim 15 where the pipes are pressure vessels.

22. The method of claim 15 where the pipes carry compressed gas.

23. The method of claim 15 further comprising:

placing a load equalizer above an uppermost row of said plurality of pipes.

24. The method according to claim 15 wherein said step of placing said load equalizer comprises placing at least one wedge between adjacent pipes on a top row of said plurality of stacked pipes and between said top row and a forcing member for passing jacking pressure from said forcing member to said pipes on said top row.

25. The method according to claim 15 wherein said step of placing a load equalizer comprises flowing a flowable material to cover at least a portion of a top row of pipes of said plurality of stacked pipes.

26. The method according to claim 25 wherein said flowable material is a concrete grout solution.

27. The method according to claim 15 further comprising a step of roughening a pipe surface or otherwise preparing a pipe surface to maximize friction between said pipes.

28. A fluid transport assembly comprising:

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

a first side support adjacent to said first side of said lower support;

a second side support adjacent to said second side of said lower support;

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

a row of spacers adjacent said lower support;

a plurality of pipes stacked in multiple rows between said first side support and said second side support in said pipe receiving area, said plurality of pipes defining an upper side, a lower side, a first side and a second side, said lower side supported by said row of spacers;

a top support above said pipe receiving area;

wherein said adjacent pipes in said plurality of pipes having two points of contact between adjacent rows and where adjacent pipes in the same row are separated from one another by a space;

a forcing member adjacent one of said sides of said plurality of pipes, 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.

29. The assembly of claim 28 wherein:

said row of spacers are a plurality of arches adjacent said lower support for supporting said plurality of pipes, said arches oriented convex side up, said arches for creating said gap between adjacent ones of said pipe in said plurality of pipes.

30. The assembly of claim 29 wherein said arches are 1/3 segments of pipe of a same size as pipe in said plurality of pipes.

31. The fluid transport assembly according to claim 28 further comprising:

a forcing mechanism for applying a force to said forcing member in a force direction; and

further comprising bracing structure for providing restraint in a direction perpendicular to said force direction.

32. The fluid transport assembly according to claim 28 further comprising:

stress spreading structure for spreading concentrated stresses generated by compressive forces exerted by said forcing mechanism.

33. The fluid transport assembly according to claim 32 wherein said stress spreading structure is a layer of empty pipe between said forcing mechanism and said plurality of pipes.

34. The fluid transport assembly according to claim 32 wherein said stress spreading structures is a layer of empty pipe surrounding said plurality of pipes.

35. The fluid transport assembly according to claim 28 further comprising a means for connecting each one of said plurality of pipes to a filling or emptying mechanism.

36. The fluid transport assembly according to claim 28 wherein:

said plurality of pipe defines an outer layer of pipe and an interior grouping of pipe; and

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

37. An assembly for transporting fluid comprising:

a cargo hold on or in a transport vessel, said cargo hold including a lower support having a first side and a second side, a first side support on said first side of said lower support, and a second side support on said second side of said lower support;

a plurality of pipes for fluid containment received in said cargo hold wherein said plurality of pipes is stacked in multiple rows, wherein adjacent pipes of said plurality of pipes have two points of contact between adjacent rows of said multiple rows and wherein adjacent pipes in a same row are separated from one another by a space;

a forcing member above said plurality of pipes;

a forcing mechanism for applying a compressive force to said plurality of pipes via said forcing member, said compressive force being sufficient so that friction between pipes of said plurality of pipes prevents any significant relative movement of pipes of said plurality of pipes;

a load equalizer below said forcing member, said load equalizer engaging said forcing member and at least two pipes of said plurality of pipes for distributing said compressive force to said at least two pipes of said plurality of pipes;

a fluid line system connected to said pipes of said plurality of pipes for filling and unloading fluid to the pipes.

38. The assembly of claim 37 wherein:

said load equalizer is a pressure wedge having a force member engaging side, a first pipe engaging side, and a second pipe engaging side.

39. The assembly of claim 38 wherein:

said pressure wedge is deformable under design loading.

40. The assembly of claim 37 wherein said load equalizer is a flowable material.

41. The assembly of claim 40 wherein said flowable material is a concrete grout solution.

42. The assembly of claim 36 where said pipes of said plurality of pipes are comprised of steel.

43. The assembly of claim 37 further comprising:

a plurality of spacers adjacent said lower support for supporting said plurality of pipes, said spacers for creating said space between adjacent ones of said pipe in a same row of said plurality of pipes.

44. The assembly of claim 37 wherein:

said transport vessel comprises a top fixed deck;

said forcing mechanism comprises a plurality of jacks between said forcing member and said top fixed deck.

45. The assembly of claim 37 wherein:

said forcing mechanism comprises a tightening mechanism for permitting pressing of the forcing member onto said plurality of pipes after a first force is applied for accommodating settling of pipes in said plurality of pipes.

46. A method of transporting gas in a plurality of stacked pipes carried on or in a vessel comprising the steps of:

locating the plurality of stacked pipes in a cargo hold of the vessel wherein said plurality of stacked pipes is stacked in multiple rows;

maintaining a space between adjacent pipes in a same row of said plurality of stacked pipes;

placing a load equalizer above said plurality of stacked pipes;

forcing said pipes of said plurality of stacked pipes together so strongly that any motion of the vessel, including flexing of the vessel itself, substantially eliminating relative motion between said pipes of said plurality of said stacked pipes, or between said pipes, and the vessel.

47. The method according to claim 46 wherein said step of placing said load equalizer comprises placing at least one wedge between adjacent pipes on a top row of said plurality of stacked pipes.

48. The method according to claim 47 wherein said step of placing at least one wedge comprises locating a point of said wedge between adjacent pipes and locating a flat surface of said wedge adjacent a forcing member.

49. The method according to claim 46 wherein said step of placing a load equalizer comprises flowing a flowable material to cover at least a portion of a top row of pipes of said plurality of stacked pipes.

50. The method according to claim 49 wherein said flowable material is a concrete grout solution.

51. The method of claim 46 wherein said step of maintaining comprises stacking said plurality of pipes on a plurality of spacers for creating a gap between adjacent ones of said pipe in a same row of said pipe.