

[72] Inventor **Ernst G. Frankel**
Boston, Mass.
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 [73] Assignee **Litton Systems, Inc.**
Beverly Hills, Calif.

[56]

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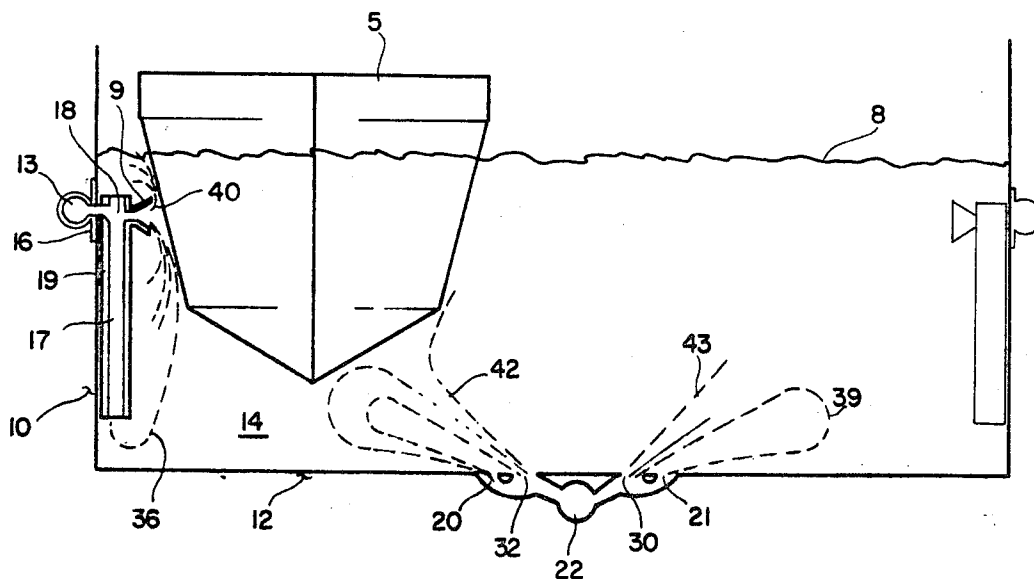
Primary Examiner—Jacob Shapiro

Attorneys—Alan C. Rose, Michael L. Wachtell, Walter R.
 Thiel and Alfred B. Levine

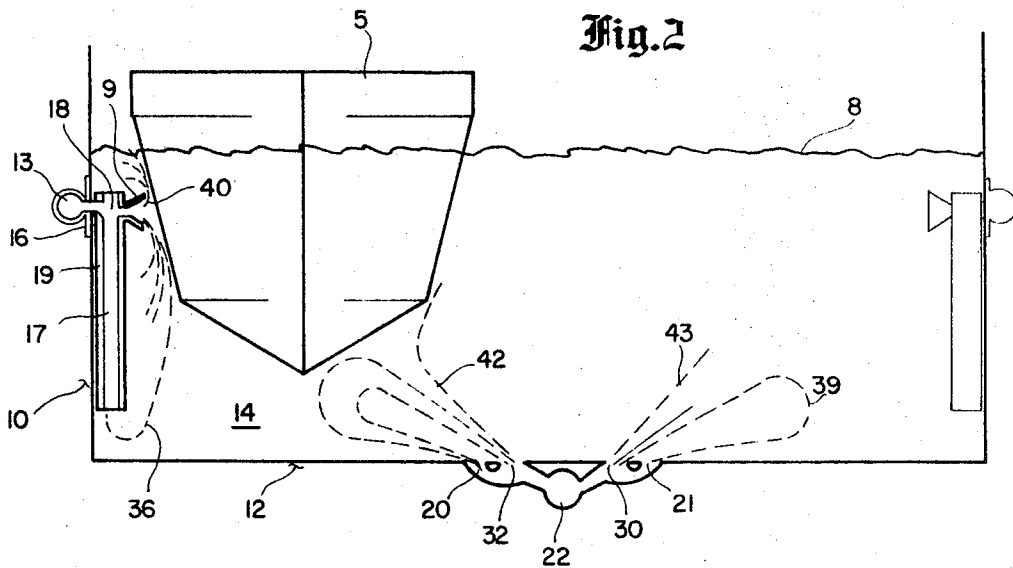
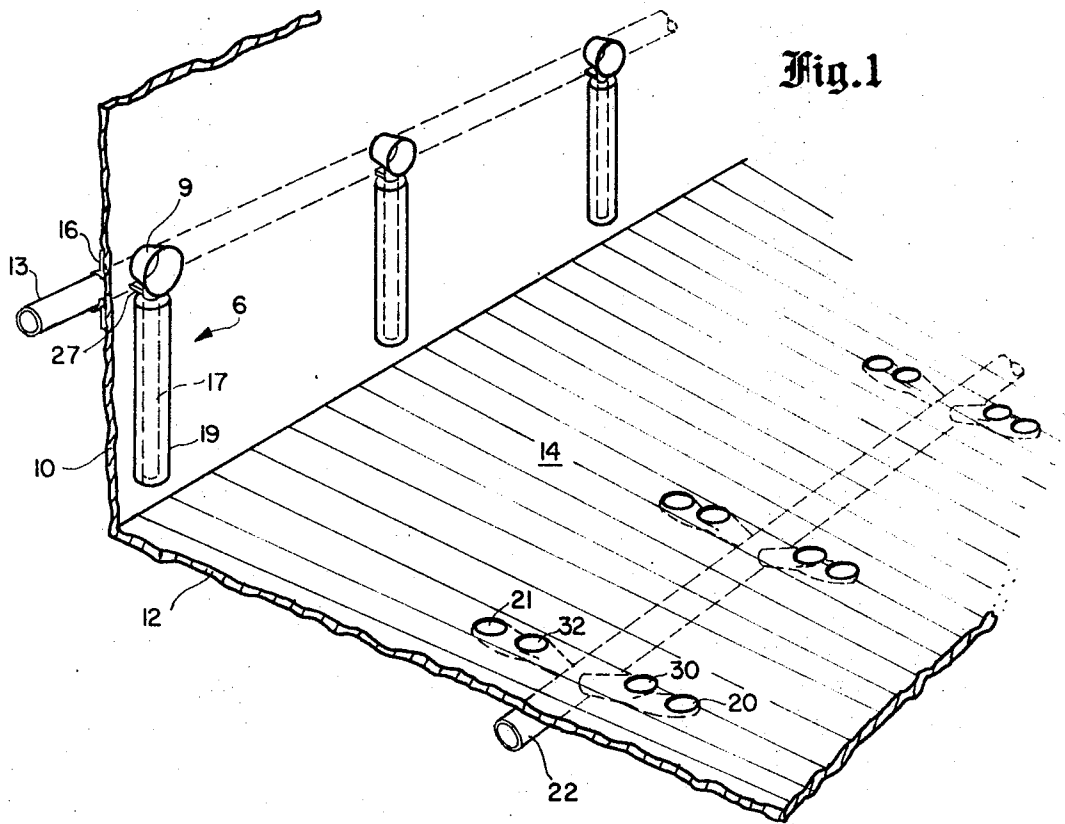
[54] DOCKING AND FENDERING SYSTEM 7 Claims, 5 Drawing Figs.

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 E02b 15/02, E02b 3/00
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ABSTRACT: A docking and fendering system for aiding in the directional guidance and fendering of vessels in channels, wells or along piers. Guidance of the vessel is achieved by hydraulic or pneumatic submerged jets directed against the sides of the vessel to direct or fender the vessel. The jets can be entirely water, air, or a mixture and are located along the wall or pier from which the vessel is to be fendered and submerged at a distance outboard from the dock so as to provide a lateral thrust on the vessel.



SHEET 1 OF 3



INVENTOR.

ERNST G. FRANKEL

BY

Michael L. Wachter

ATTORNEY

Fig. 3

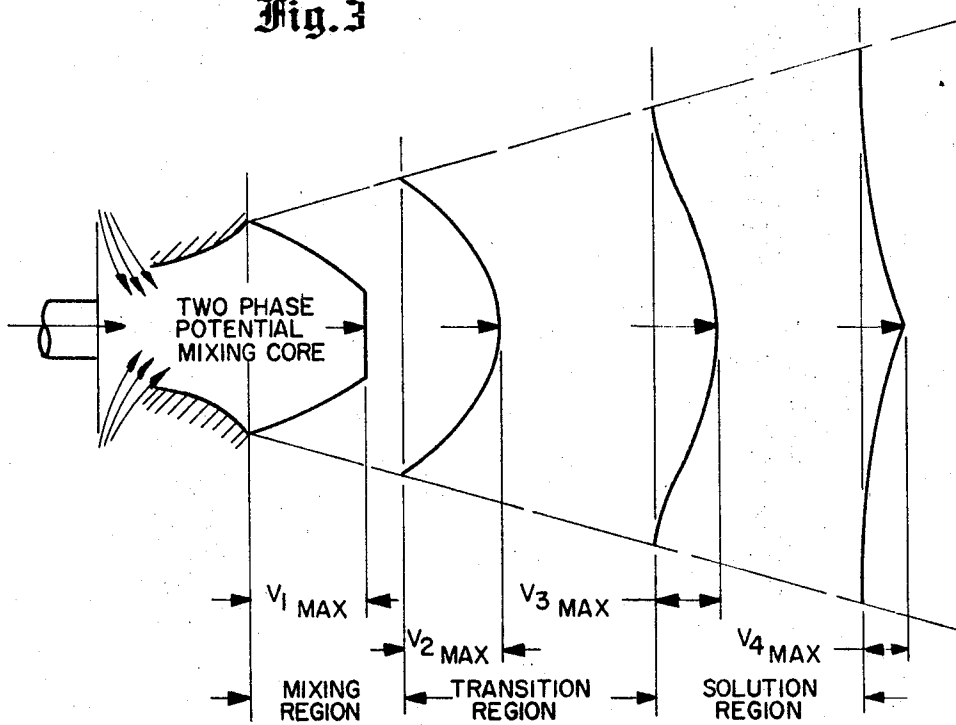
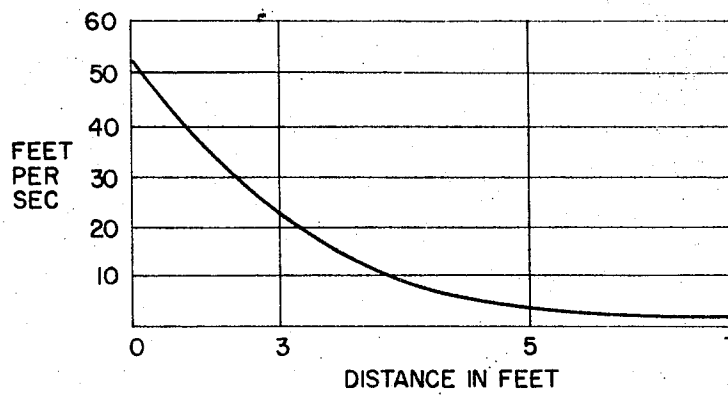
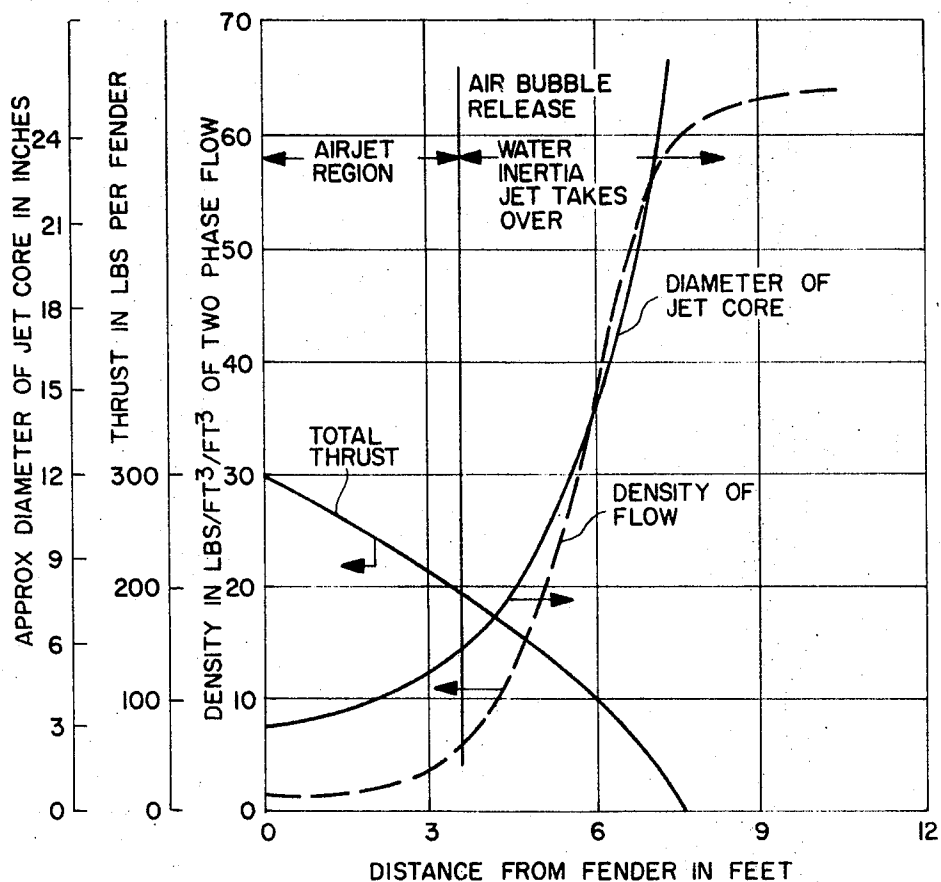


Fig. 4



INVENTOR.
 ERNST G. FRANKEL
 BY *Michael H. Wood*
 ATTORNEY

Fig. 5



INVENTOR.
ERNST G. FRANKEL

BY

Michael H. Woodgett

ATTORNEY

DOCKING AND FENDERING SYSTEM

BACKGROUND OF THE INVENTION

When docking ships, lighters or other waterborne craft in channels, ship wells or along piers, standard docking equipment using tugs and mooring lines and passive cushioning fenders have generally proved unsatisfactory. This is especially true in a heaving or pitching sea. The effective docking and fendering of lighters becomes particularly critical during the landing of craft in the well of ship such as the LHA vessels presently being designed and constructed by Ingalls Shipbuilding Division of Litton Systems, Inc., Beverly Hills, California for the United States Navy. While mooring lines will provide a positive retaining force towards a pier or dock, they will not provide positive directional control to keep a vessel on course at low or zero speed, nor will they prevent severe impact with the sides of the dock in a turbulent sea. Lines are also incapable of directly providing a forward or aft thrust on the vessel to allow positioning along the dock. Tugs can provide the active control needed but they are impractical for use within a narrow channel or a ship's well.

Within the narrow well of a ship the heaving and pitching motions of the sea are magnified due to the reflective action of the walls on waves within the well. When landing vessels within a ship well, it is necessary to maintain the vessels on course at low and zero speeds so as to assure lateral separation of the vessels and also provide effective fendering during docking operations.

Prior ship-well docking and fendering systems have utilized a combination of mooring lines to provide a positive control and heavy fenders to dampen the impact against the well. Protective fendering devices such as resilient fenders along the sidewalls and bulkheads will dampen the impact of gliders against the well walls, but they do not provide effective, positive retention of the vessels. None of the previous systems used have the ability to provide fendering and at the same time impart and control directional stability of the vessels.

It is therefore an object of this invention to provide a docking and fendering system that will provide active fendering action and directional guidance to a vessel as it is docked.

An additional object of the invention is to provide a fendering and docking system that will fender and guide vessels docking within a narrow channel or well of a ship thereby assuring lateral separation of the docking vessels from adjacent vessels.

Another object of the invention is to provide a docking and fendering system for waterborne craft in narrow channels or other restricted passages by providing nonmechanical side thrusts to guide the vessels.

Another object of the invention is to provide a docking and fendering system that will positively retain the vessel against the dock or side of a well after it has landed.

Still another object of the invention is to provide a fendering and docking system for the well of a ship which will additionally decrease and dampen surface waves within the well and reduce current and surge forces of a turbulent sea.

SUMMARY OF THE INVENTION

In accordance with one aspect of my invention a series of pneumatic and/or hydraulic jets are provided along the wall of the ship well or along a pier or dock, which will strike the docking vessel in such a way as to provide a lateral thrust along the length of the docking vessel thereby actively fendering the vessel from severe impacts with the wall or dock. Additional jets are submerged on the outboard side of the vessel to provide a similar thrust to guide the vessel towards the dock at a controlled rate. The direction of the jets can be varied to urge the vessel in a forward or aft direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The specific nature of the invention, as well as other objects, aspects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawings in which:

FIG. 1 is a perspective view of the arrangement of a docking and fendering system in accordance with my invention shown as a cutaway portion of a ship well.

FIG. 2 is a schematic representation of the arrangement of the docking and fendering devices shown in FIG. 1 which illustrates the operation of docking a ship.

FIG. 3 is a pictorial representation of the velocity distribution of a 2-phase jet as a function of distance from a jet used in my invention.

FIG. 4 is a graph illustrating the velocity distribution of a fluid exiting from the jets used in my invention.

FIG. 5 is a graph of the air/water jet parameters used to demonstrate the operation of my invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The jets produced by the converging-diverging nozzles located along the sidewalls and bottom of the ship well can consist of a simple high pressure submerged water jet fed by a high pressure hydraulic source, or the velocity of the hydraulic jet can be decreased and its mass rate of flow increased through a similar converging-diverging nozzle with a venturi section at the point of convergence which serves to raise water into the jet nozzle and eject the mixture of a high pressure and suction water in a smaller velocity with greatly increased mass.

This latter principle can also be used as a third alternative by applying high pressure air through the converging-diverging nozzle to provide the suction force needed to raise the higher density water into the nozzle mixing chamber where it mixes with the air producing a 2-phase jet. The proportions of water to air in the 2-phase jet will be defined by the suction head, the nozzle design, and the diameters of the water and air supply pipes.

The choice as to which of the three alternatives is to be used depends on the requirements of jet penetration versus jet reaction force as a function of distance from the nozzle exit. While the 2-phase jet has been particularly referred to in the descriptions of FIGS. 1 and 2, it should be apparent that all three alternatives are well within the scope of my invention.

FIG. 1 illustrates the arrangement of my docking and fendering system within the well of a ship. A plurality of fendering devices 6 are mounted at predetermined intervals along the wall 10 of the ship well 14. The fendering devices 6 are submerged in the well so that the converging-diverging nozzles 9 are submerged just below the water level. A high pressure air supply pipe 13 for supplying power to the nozzles 9 is fastened along the inside of wall 10 by a series of brackets 16. Water from the well is supplied to the nozzles 9 through intake pipes 17 located within resilient cushions 19 and open to the water near the bottom of the well. Each fendering device 6 is connected to wall 10 by brackets 27. While not shown in the FIG. for purposes of clarity, a similar series of jets is provided along the right wall of well 14 to fender vessels docking on that side.

Lateral thrust on the landing craft towards the left and right sidewalls is provided by similar 2-phase jets from a series of converging-diverging nozzles 30 and 32 located in the double bottom 12 of the ship well 14 and aligned in rows equidistant either side of the centerline. The nozzles 30 and 32 are supplied with air from the high pressure supply pipe 22 mounted within double bottom 12. Water is supplied to the mixing chambers of nozzles 30 and 32 through a series of water intakes 20 and 21.

Operation of the fendering and docking system of FIG. 1 can be more readily understood by referring to the schematic representation of FIG. 2. The landing craft or lighter 5 to be docked along the left wall 10, enters the ship well 14 floating on the surface of the water 8 between the wall 10 and the centerline of the well. The craft is fendered from the wall 10 by

high velocity jets 40 from the nozzle 9 of each fendering device 6 which act on the vessel at a point just below the surface of the water 8. The jet 40 in each fender is produced by air supplied from the pipe 13 being forced into a mixing chamber 18 at a high pressure where it mixes with water lifted from the bottom of the well 14 through pipe 17 by the venturi suction created at the point of convergence in the nozzle 9. The mixture of air and water is then ejected into the well 14 as a 2-phase jet 40. After the jet loses momentum, a portion of the water in each jet 40 will recirculate back to the intake pipe 17 approximately along the dotted path 36. A deep resilient fender 19 is provided around the water pipe 17 to help dampen the vessels against severe docking impacts in an extremely turbulent sea and to also protect the pipes 17 from damage. To provide additional fendering and to prevent the destruction of the jet nozzles, the jet nozzle 9 is constructed of a resilient rubber which will give under impact with a colliding vessel. Other fendering may of course be provided directly on the sides of the landing vessel for additional protection.

Whenever a docking vessel comes under the influence of a jet 40 from one of the fendering devices it will simultaneously have a lateral thrust applied thereto along its outboard side by a 2-phase jet 42 from one of the bottom nozzles 32 aligned along the left side of the centerline. Each of the jets 42 is produced by mixing air from the high-pressure supply 22 with water supplied through one of the water intakes 20. Similar jets 43 are provided through nozzles 30 and intakes 21 for ship docking along the opposite wall. The 2-phase jets from the bottom nozzles 30 and 32 are ejected from the nozzles at an upward gradient of about 40° towards the docking vessel. The resulting lateral force produced along the sides of the docking vessel by the several submerged jets assures lateral separation and positive directional control of the docking vessels even at low or zero speeds. The nozzles 30 and 32 are also designed to assume a forward or aft angle to produce a small forward or aft thrust for the positive movement of vessels into or out of the well. Because the jets used in my invention can be either a sample high pressure submerged water jet, a purely submerged air jet or a combination 2-phase jet, the particular characteristics and effectiveness of the different combinations must be based upon extensive theoretical and experimental studies of the several alternatives.

The results of engineering and analytical studies generally indicate that 2-phase submerged jets described in FIGS. 1 and 2 provide the best tradeoff with regard to pressures, velocity, effective thrusts and ease of control. The results of these studies are graphically represented in FIGS. 3, 4 and 5.

Assuming a maximum air supply pressure of 34.9 p.s.i.a., various pipe and nozzle diameters were combined to derive the best set of dimensions for maximum jet efficiency. The most effective jet from a momentum transfer and jet penetration point of view was the combination of a 4-inch internal diameter manifold pipe equipped with 1½ inch internal diameter Barda-type nozzles.

Computations and experimental data indicated that the optimum mixture for our purposes was a ratio of 95:1 in volume of air to water ejected. The mean air velocity increases from about 160 f.p.s. in the supply manifold to about 700 f.p.s. in the nozzles at the point of convergence. At the nozzle the mixture of water and air has a density of 2.2 lb./ft.³ and a velocity of 53 f.p.s. (designated as $V_{1\text{ MAX}}$ max in FIG. 3). The mixing region in which the jet can be assumed to retain a less dense core is estimated to extend for about 3 feet under a head of 4 feet of water.

As illustrate in FIGS. 3 and 4, the velocity of the jet reduces to $V_{2\text{ MAX}}=20$ f.p.s. at a point 3 feet from the nozzle and to $V_{3\text{ MAX}}=3$ f.p.s. at a point about 5 feet from the exit when its density reaches about 10 lb./ft.³. The large increase in density at

distances in excess of 3 feet from the nozzle appears to be due to the replacement of the core made up largely of air, by an ever increasing content of water, when the air separates and vents from the jet as rising bubbles. Beyond 5 feet the horizontal momentum of the jet is due almost entirely to the inertia of the water. The resultant velocity distribution is an asymptotic decrease in the velocity as a direct function of the distance from the jet exit.

FIG. 5 is a graphic illustration of the tradeoff between a pure air jet submerged under water with resultant high jet penetration versus early mixing of the air jet with a large body of slowly moving water inside the jet nozzle.

Using the velocity distribution of the submerged jet to derive total resulting pressure on a flat surface projected by the side of a lighter or landing craft, it is found that pressures of several hundred pounds can be achieved with reasonable nozzle diameters and jet velocities.

In addition to providing effective and controllable lateral thrust for fendering and course keeping of lighters in the well, the submerged jets also appear to generate substantial near-surface turbulence which effectively helps dampen surface waves and reduces current and surge forces in the well.

The jets can also be used to retain lighters against one side of the well by inducing differential lateral jet thrust on the port and starboard sides of the lighter when in a docking position. This becomes especially important where quick loading and unloading of the lighter is desired and the use of mooring lines would be a waste of time.

The docking and fendering system generally eliminates the need for line handling. Of course, when sea withdrawn are less ideal the docking operation would have to be made at a slow enough speed to insure that the jets can take control. In such situations more conventional mooring systems can be used to augment the described system.

I claim as my invention:

1. A system for docking and fendering a vessel alongside a mooring comprising:

- a. first jet means mounted on a dock to provide a lateral thrust on the inboard side of said vessel as it approaches said mooring;
- b. second jet means submerged in the water at a distance away from said dock to provide a lateral thrust on the outboard side of said vessel in a direction opposite to that applied on the inboard side by said first jet means;
- c. a first high pressure power source to supply a high pressure fluid to said first jet means; and
- d. a second high pressure source to supply a high pressure fluid to said second jet means.

2. The system of claim 1 wherein said first and second jet means each include a converging-diverging nozzle to cause the high-pressure fluid flowing therethrough to follow a converging-diverging path.

3. The system of claim 2 wherein said high pressure fluid is water.

4. The system of claim 2 wherein said high pressure fluid is air.

5. The system of claim 4 wherein each of said jet means further includes a water intake disposed so that the high pressure air flowing through said nozzle will mix with water before exiting from said first and second jet means.

6. The system of claim 5 wherein said second jet means can be adjusted to provide a thrust on the docking vessel so as to cause the vessel to move in a forward or aft direction.

7. The system of claim 6 wherein each of said first and second jet means comprises a plurality of converging-diverging nozzles connected to said first and second high pressure power sources respectively to provide a plurality of thrusts along the inboard and outboard sides of the vessel.