Aug. 21, 1956 K. E. FIEBINGER ET AL 2,759,331

BERTHING PIER

Filed Oct. 14, 1954 3 Sheets-Sheet 1

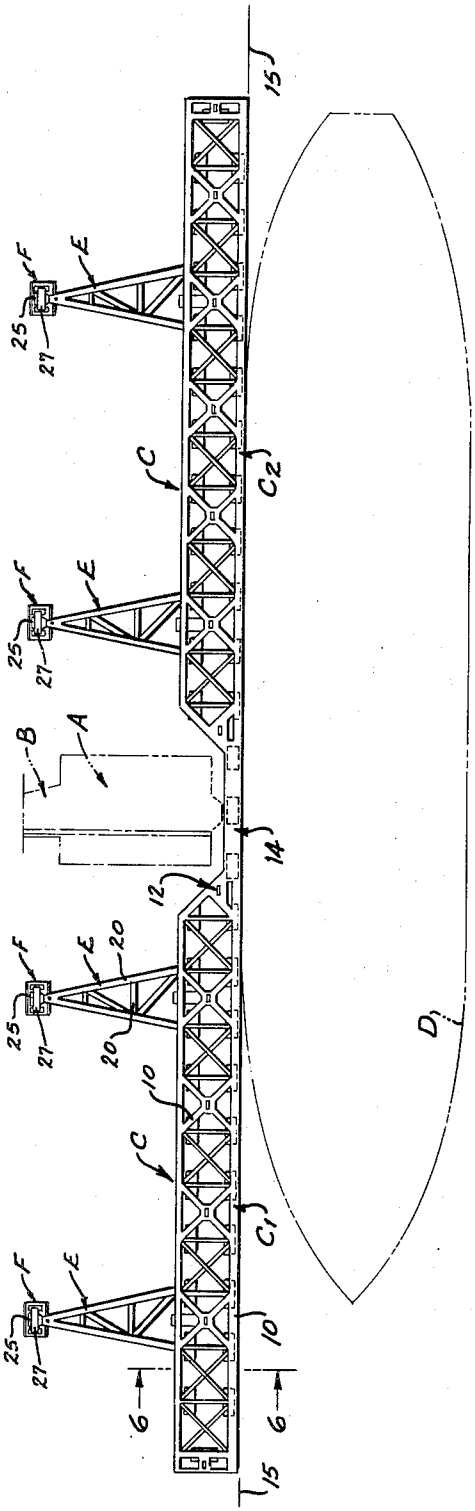


FIG. 1

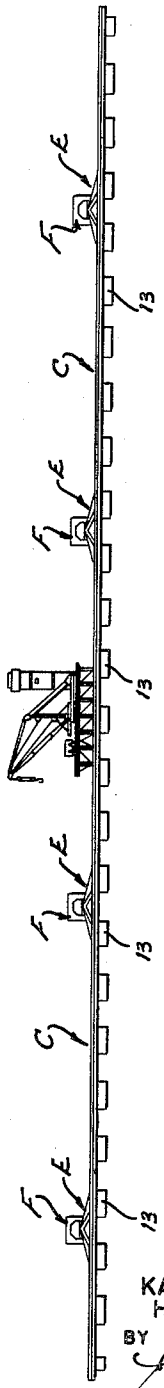


FIG. 2

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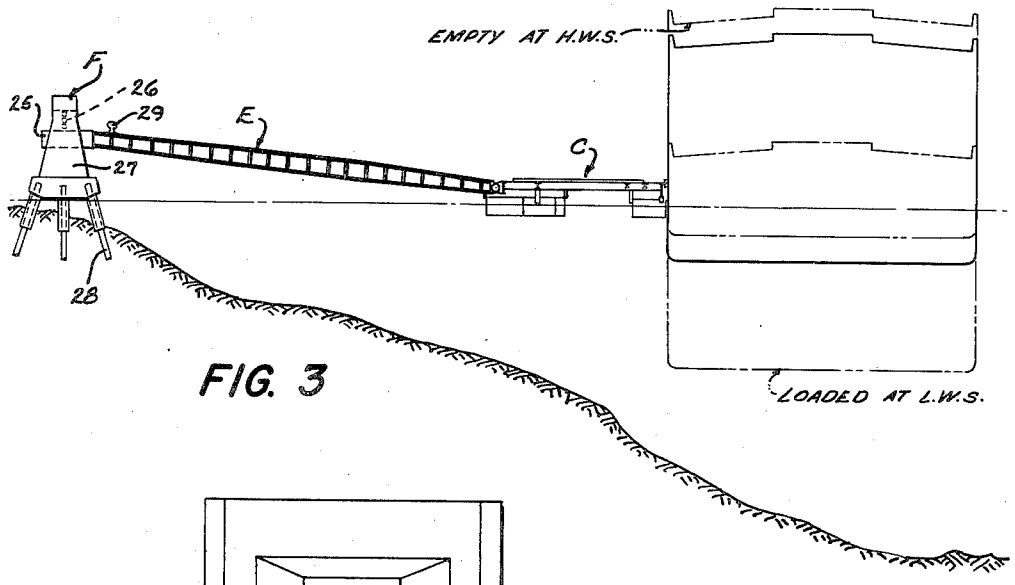


FIG. 3

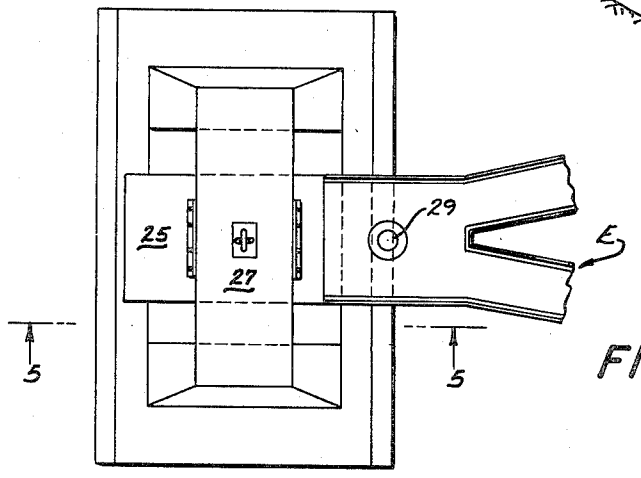


FIG. 4

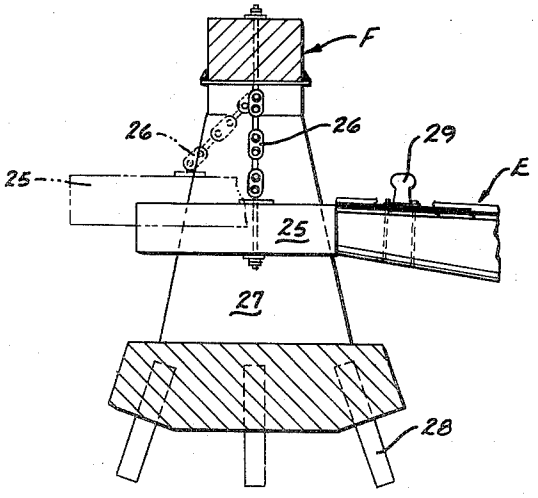


FIG. 5

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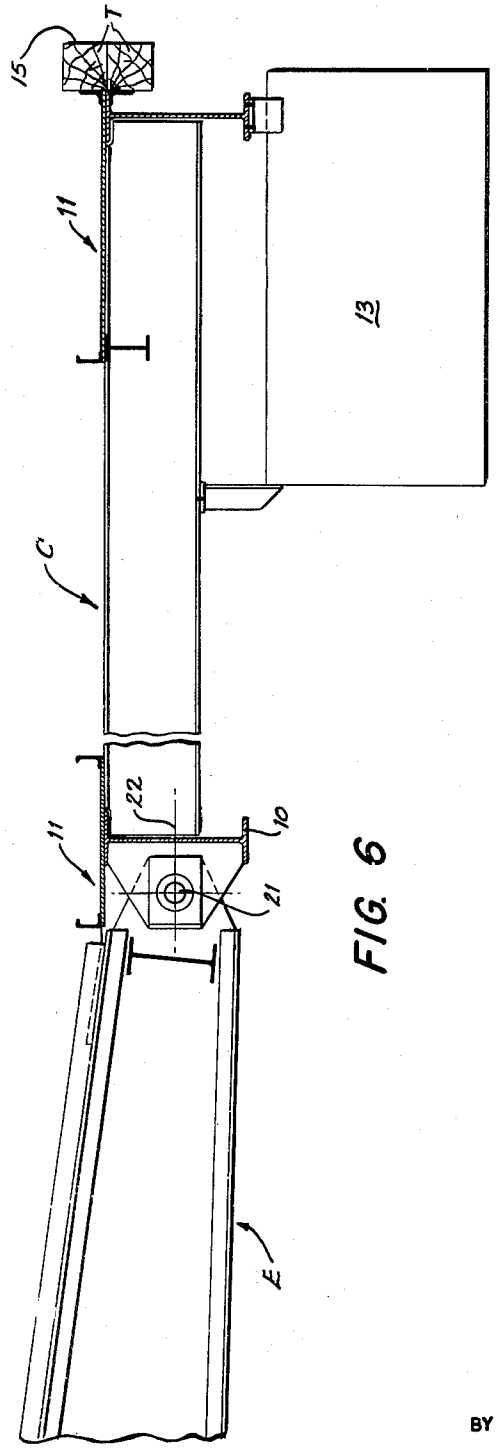


FIG. 6

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2,759,331

BERTHING PIER

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Application October 14, 1954, Serial No. 462,295

7 Claims. (Cl. 61—48)

This invention relates to berthing piers.

Berthing piers as heretofore constructed have generally consisted of a rigidly supported pier structure carrying spring or other shock absorbing fenders, or have taken the form of floating structures held in place by chains and moorings. In either case, the pier anchorages or deadmen require installation in deep water and involve heavy and expensive marine construction.

The present invention provides a berthing pier installation in which the pier structure or wharf may be floated in sufficiently deep water to take vessels of any required draft, while the anchorages are located shoreward in shallow water or on the shore or upon any available rock formations. The floated pier mass and water resistance are available for absorbing and damping impact by the vessel, while the balance of the impact energy is taken up at the anchorages, thus avoiding any deep water mooring or anchorage installations. The structures are also adapted to prefabrication and installation by mere assembly operations involving no deep water caisson or diving work.

In a typical installation the berthing pier structure proper comprises a truss floated by means of pontoons and held in place by spars or booms extending to shoreward points of attachment. The floating truss structure may move freely with the vessel, except as restrained by its own inertia and water resistance, until resistance is built up at the anchorages. The booms are preferably attached to the anchorages by chain suspensions, or similar means permitting universal movement, and the suspensions are arranged to absorb the required impact energy by elevating a weight or weights of sufficient mass. At the same time, windload and water current forces are likewise counterbalanced, and the entire floating truss structure may be held in a practically fixed location under all normal conditions.

An installation embodying the invention in a preferred form will now be described with reference to the accompanying drawing, and the features forming the invention will then be pointed out in the appended claims.

In the drawing:

Figure 1 is a schematic plan view of a berthing pier, with loading pier and vessel indicated in phantom outline;

Figure 2 is a front elevation of the structure of Figure 1;

Figure 3 is a side elevation;

Figures 4 and 5 are, respectively, an enlarged plan view, and section on line 5—5 of Figure 4, of one of the anchorages; and

Figure 6 is an enlarged sectional view showing the floating pier structure in section on line 6—6 of Figure 1.

The installation shown by way of illustration in the drawing is an ore loading station, where the fender line of the berthing pier is located about one hundred and fifty to two hundred feet from the shore line, in deep enough water to allow the docking of loaded vessels. The spars are about one hundred feet long, this length, when

added to the width of the berthing pier floating structure being sufficient for locating the anchorages in shallow water and generally above mean sea level.

The general elements involved in the installation include a loading pier A and trestle B for providing access by railway or truck, which elements are rigidly mounted on piles or caissons in the usual way. The floating truss C, against which the vessel D is berthed, is held in proper position relative to the loading pier A by spars E extending to the anchorages F. A movement of a few feet suffices to counterbalance any wind or other forces which may exist, so that the truss C is held in substantially fixed position with respect to the loading pier.

Impact of the vessel against the floating truss is communicated through the spars E to the anchorage points F where it is absorbed by raising weights (as later described) to the height required to convert the kinetic energy into potential energy. Thereafter, the weights return the entire system, including spars, truss and vessel to the position at time of impact. By reason of the high damping factor of the structures and water, there is little or no overshooting in this movement, and hence no undue strain on the mooring lines.

The floating truss C may take various forms, but conveniently is built of structural steel shapes **10**, welded, riveted or bolted together in the usual way to form the truss. The structure provides catwalks **11** and carries cleats or kevels **12** for attaching moving lines. Pontoons **13** serve to float the truss C. The fender line may carry timbers T, as indicated in Fig. 6, acting as buffers contacting the vessel. Any other of the usual fending or buffing devices, such as ropes or rubber tubing may be used at this point.

In the case shown, the truss has an overall length of about 1000 feet and comprises two sections C1 and C2 joined by a narrow beam or girder **14** which extends across the loading pier, and underneath the overhang thereof. The fender line **15** is thus brought close into the loading pier.

The spars or booms E are formed of structural steel shapes **20** and are preferably A-shaped in plan as indicated, to fix their shoreward ends more or less rigidly, in their plane, with respect to the floating truss. The booms thus form a frame structure permitting vertical movement of the floating truss but capable of holding it in position in a horizontal plane. The booms E are preferably attached to the truss by hinged joints **21** to permit pivoting about an axis **22**, which is preferably horizontal and parallel to the fender line.

The shoreward ends of the booms E carry weights **25** and are supported by chains **26** hung from arched supports **27** supported by piles **28** or in any other convenient manner. The weights **25** may be reinforced concrete blocks or boxes filled with rubble, or may take any other convenient form, in view of locally available materials. The booms E also carry cleats or bollards **20**, near the anchorages, for attaching mooring lines or spring lines.

While the invention is not limited to installation of any particular dimensions or proportions, one set of designed conditions will now be given, in some detail, for purposes of discussion and by way of illustration, in order to clarify the details of construction or operation.

The installation shown is designed for berthing and loading of ore ships with 24,000 tons loading capacity, the "light" ship or ship with required ballast having a displacement of 14,000 tons (31,000 kips). Maximum impact will occur at a speed (dead ahead) of about three knots, when steerageway is lost, associating with a maximum angle of about 13° to the fender line. The kinetic energy component perpendicular to the fender line is thus about 610 foot kips of which about 40% or 245 foot kips, is to be absorbed by the anchorages. In this installation,

the weights 25 each weigh about 200 kips. A movement of the floating truss perpendicular to fender line will lift the weights 25. A lift of two of the weights about seven and one half inches will absorb the energy of 245 foot kips. The chain length suspending each weight is about 7 feet, giving a horizontal movement of a little over three feet to produce the required lifting of the weights, and creating a maximum total contact force of 180 kips.

As will be noted, a lateral clearance (parallel to fender line) between weights 25 and the legs of the arches 27 supporting them is provided, and this clearance is between three and four feet, so that this amount of horizontal component of motion is permitted in this direction. Kinetic energy of the ship parallel to the fender line is partially taken up in friction against the fenders, which force is transmitted to the anchorages by the spars E, causing a horizontal displacement parallel to fender line of the weights and corresponding vertical movement.

Assuming a friction coefficient of 0.25 between ship and fender, the maximum of the friction force will be 45 kips or an average of approximately 22 kips. This force will act for about ten seconds, the time needed for the swinging forth and back of the weights. During this time the ship moves 50 feet parallel to the fender line. Thus a work of about 2,200 foot kips will absorb 10% of the kinetic energy of the ship, 11,000 foot kips in the assumed case, and slow down the speed of the ship.

The friction force and the counterforce at the weights create a couple with moment arm equal, in the case under consideration, to about 150 feet. This couple is balanced by a difference in horizontal components of movements of the weights 25 perpendicular to fender line, which differential movement may be relatively small since the moment arm between the two end anchorages F may be relatively great, and in the case illustrated is about 750 feet, or five times as great as the moment arm for the couple in the contrary sense.

Of the other forces involved, the wind load on the ship is obviously by far the greatest and may be, in the illustrative case, about 400 kips. Such a wind force will cause all weights to be lifted a different amount, of which the maximum will be 34 inches corresponding to a horizontal movement of 68 inches.

The shoreward ends of spars E are preferably somewhat elevated, as shown, the extent of elevation with respect to the floating truss C depending upon the tide, which will vary with the location but is, in any case, a known factor. In consequence, the force of the truss pressing against the spars at their pivot points will create a downward component tending to submerge the shoreward edge of the floating truss C more deeply in the water and increasing the damping effect of the water resistance as well as absorbing a minor part of any impact. An additional cushioning effect is thus provided.

The structure disclosed may be considered as two relatively rigid floating truss sections C1 and C2, with the girder 14 forming a joint or hinge between them, by reason of its greater flexibility, and even under this extreme assumption, will take and transmit the impact in a satisfactory manner.

The pier structure may be comparatively light, the spars E weighing, say, 40 kips apiece and the floating truss C about 1900 kips, in the case illustrated. The parts may be brought in any convenient subassemblies and the assembly completed with a minimum of work at the operating location. In addition to absorbing impact energy and holding the pier and vessel in position against wind and water forces, the weights 25 may serve to counterbalance the spars E to any desired extent. Thus, for example, a weight 25 may be hung at a point two feet from its center of gravity, creating a couple of 400 foot kips partly counterbalancing the weight of the spar E and relieving, to that extent, the load on the truss C and reducing the pontoon volume needed to float it. It will thus be noted that the weights 25 do not necessarily add to the floated weight, but may be suspended so as to reduce it or not affect it, thus not interfering with the otherwise desirable mass relationships.

Generally speaking, the mooring lines will go to the kevels 12 and spring lines will be attached to the shoreward bollards 29. Since the truss C floats with the vessel, tide changes will require no adjustment of the lines attached to the kevels 12 and the angles and distance involved will also be such as to require no adjustment of the spring lines running to the bollards 29. Thus, engines for relaxing the line tension will ordinarily be required only to provide against unusual conditions, such as very heavy sudden gusts of wind, and may, in many cases, be dispensed with entirely.

While the anchorages F have been shown as equally spaced and aligned parallel to the fender line 15, it will be apparent that this is not essential. For example, if rock formations are available for mounting the anchorages, it may prove advantageous to utilize such formations for one or more anchorages, thus spacing the anchorages at unequal intervals along the pier and at unequal distances from the fender line.

The truss C, and its sections C1 or C2 need not be rigid but may possess substantial flexibility. For example, a section C1 or C2 may deflect, in the case chosen for illustration (horizontally and at right angles to fender line), through about an inch under a centrally applied relatively small concentrated load. In the nature of the case the resulting concave curvature immediately tends to distribute the load, by bringing the fender line more nearly into conformity with the curvature of the side of the vessel.

What is claimed is:

1. A berthing pier installation comprising a floating pier element, a plurality of spars attached at one end to the said element for holding it in position to berth a vessel, relatively rigid anchorage means, a plurality of weights, means suspending the said weights from the anchorage means for pendulous movement and means attaching the other ends of the said spars to the said weights, whereby movement of the floating pier element from a position corresponding to the lowest position of the said weights stores energy by raising the weights and creates an increasing resistance to such movement.

2. A berthing pier installation comprising a floating pier element, an anchorage, and means for holding the floating pier element in substantially fixed horizontally spaced position with respect to the anchorage, the said means comprising a framework connected to the floating pier element, a chain hanging the other end of the framework at the anchorage, and a weight supported by the said chain, whereby movement of the floating pier element from a position corresponding to a vertical position of the chain is resisted, and impact energy causing such movement is absorbed by lifting the weight.

3. A berthing pier installation according to claim 2, comprising a plurality of such frameworks attached to the floating pier element along its length and so connected at a plurality of anchorages.

4. A berthing pier installation comprising two floating pier elements according to claim 2, means connecting them together along a common fender line, and a loading pier positioned between the two said floating pier elements for loading a vessel berthed against the same.

5. A marine installation comprising a floated member, a plurality of anchorages, a framework for holding the floated member in position relative to the anchorages, connections between the framework and the floated member and connections between the framework and the anchorages, the last said connections comprising pendulous suspensions hanging the frame from the anchorages and including weights, whereby the last said connections tend to hold the floated member in a position where the weights are at the bottom of their swing and resist displacement from that position.

6. A marine installation according to claim 5, in which the said pendulous suspensions permit limited free movement in all directions.

7. A marine installation according to claim 6, in which the said pendulous suspensions comprise chains hanging the said weights and the said weights are fixedly attached to the framework.

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