April 21, 1970 MISAO MIURA 3,507,123

FENDER FOR DOCK WALL

Filed Feb. 20, 1968

FIG. 1.

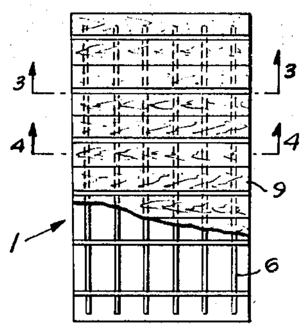


FIG. 2.

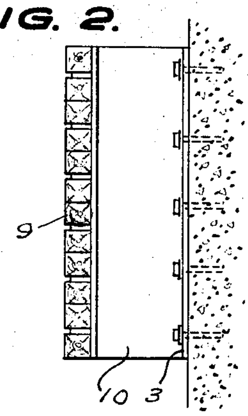


FIG. 3.

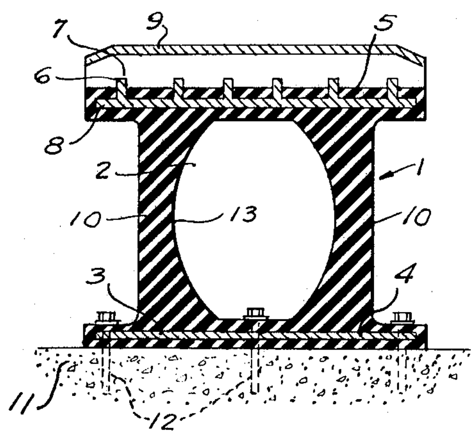


FIG. 4.

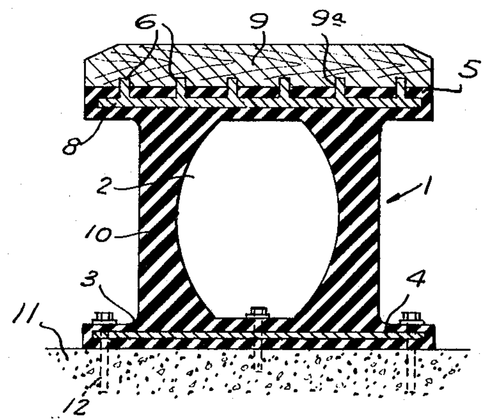


FIG. 5.

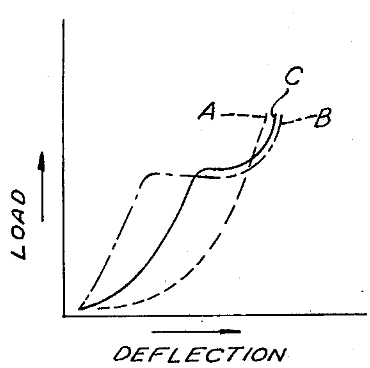
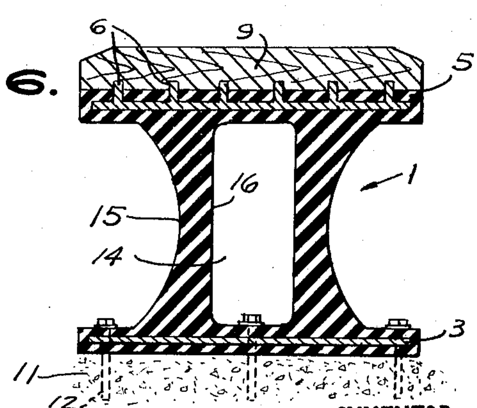


FIG. 6.



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3,507,123
FENDER FOR DOCK WALL
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U.S. Cl. 61—48 2 Claims

ABSTRACT OF THE DISCLOSURE

A flexible hollow tubular fender for a dock wall is provided, having a base and a top buffer, and an intermediate resilient block which is hollow and has lateral sides which are each of a non-uniform cross-section.

The present invention relates to a fender to be fitted to a quay or dock wall for the purpose of absorbing the dynamic energy of a ship on being moored in a port so that it can be safely moored without damaging the hull or the quay wall structure.

In recent years ships are becoming ever bigger. Particularly oil tankers or ore-carriers of 100,000–300,000 metric tons classes are being produced. With a tremendous kinetic energy present in such giant vesels in mooring, a more effective cushioning device to protect the hull and the mooring dock structure is now urgently in demand.

There are at present a variety of types of mooring fenders available for this purpose, and most of them make use of the elasticity of rubber and come in fairly large sizes. In their design, however, the major emphasis is laid on the absorption of the dynamic energy of mooring, and little attention is paid to the possibility of hull damage or to the economy of mooring structures. The fundamental requirement as to the fender is to absorb as much impact energy as possible by a minimum reaction. The existing rubber fenders are found to be nearly satisfactory as far as the ability of rubber elasticity to absorb the energy is concerned. But the existing rubber fenders are disadvantageous in that the better they can absorb the energy, the larger the reaction they cause.

In the conventional design of such fenders, the contact area between the rubber elements and the hull is small. This results in the development of a large compression stress in the contact area between the outside plating of the hull and the fender, which causes hull damage and may lead to an accident. The compression stress developed on the part of the surface of the hull in direct contact with the conventional fender is equal to about 60–150 metric tons per square meter, whereas the critical loading strength of the outside plating of the hull is about 30-40 metric tons per square meter. Thus due to the application of a stress far in excess of the allowed loading strength, the outside plating of the hull is often subjected to damage. The present practice now used as a countermeasure for this condition is to provide combined wooden boards over the rubber fender to avoid direct contact of the outside plating of the hull with the rubber fender, or to provide driving piles and erecting a concrete wall on the heads thereof.

The magnitude of the reaction depends to a large extent on the sectional area of the members constituting the mooring structures. The smaller the reaction, the more economical will be the structure required.

Generally speaking, the structural designing of mooring facilities can most reasonably be made in consideration of the magnitudes of the mooring speeds and their frequency distribution. The mooring speed which has been taken as

a design factor will not always be the one met in practice, and a ship will more often approach the quay at a considerably lower speed than that. It would be appropriate for designing to assume the reaction due to a higher mooring speed of less frequency as a short-term load, and provide a certain margin for the allowable stress of structural members for this load, while designing an allowable stress under a long-term load for the reaction due to a lower mooring speed of more frequent occurrence. Such a designing method would give economical sections of the structural members, but the actual designing in practice is influenced by the characteristics of a fender. For instance, take the case of a circular fender in which the relation between the magnitude of applied force of reaction and the involved strain gives a linear variation. In such a fender there is a desirable tendency that the applied force of reaction is small in the range of small energy absorption and the force of reaction increases with an increase in the absorbed energy. However, this type of fender has drawbacks in that the total energy absorption is too small and a firm fitting is difficult to attain.

In the case of a V-shaped fender, as heretofore used, the reaction rises to a certain extent in the initial stage, thereafter remaining constant while the strain continues to grow; accordingly there is no proportional relation between energy absorption and reaction, and a large reaction occurs even in the range of small energy absorption. Such a fender should be designed assuming an allowable stress under a long-term load for the section of structural member against a large reaction in the initial stage. Thus, with an increased section required, the resulting structure will be less economical.

The ideal relation between the magnitude of reaction and energy absorption would be represented in the initial operating stage by small energy absorption by the reaction of a circular fender, and in the later operating stage calling for large energy absorption by the reaction of a V-shaped fender.

The present invention has been developed in view of the above points. The following is a description of embodiments of the present invention, referring to the accompanying drawings, in which

FIGURE 1 shows a side elevation of a fender according to this present invention;

FIGURE 2 shows a side view of said fender;

FIGURE 3 shows an enlarged cross-section of FIG. 1 along the line III—III;

FIGURE 4 shows an enlarged section of FIG. 1 along the line IV—IV;

FIGURE 5 shows a comparison of characteristic curves to illustrate the relation between the load and the deflection against the fenders; and

FIGURE 6 shows a modified form of the fender in which outer faces of the fender are concave instead of flat.

Referring to the drawings, the main body or principal part **1** of the fender is an approximately rectangular tube with an approximately elliptical bore **2** running longitudinally through its center and is preferably of rubber or other resilient material. The base **3** of said main body or principal part **1** has a core plate **4** of iron or other material embedded therein. It would be desirable to extend the base **3** outside of the wall of the main body so that said fender base may be easy to fix to the quay wall as by bolts **12**. On the side of the fender, opposite to the base **3**, there is a buffer member **5**, in which is embedded a core plate, preferably of metal, **8** and that is a grid-form consolidation of longitudinal beams **6** and transverse beams **7** of iron and other material, with the top surfaces of said beams being exposed. In this embodiment, the transverse beams **7** are inserted to be higher than the longitudinal beams **6**. In each of the spaces between adjacent pairs of transverse beams **7**, there are arranged two pieces of wood **9**, on one edge of which notch or groove **9***a* are cut to receive the protruding edges of longitudinal beams **6**. The beams of core plate **8** to be embedded in said buffer **5** are intended to prevent a deflection of core plate **8** and to distribute the applied load in that area. Therefore said pieces of wood **9** may be covered with rubber. The side faces of the portion of the fender between the base **3** and the buffer **5**, and the outside fender face is flat and perpendicular to the base, and the inside surface thereof is warped outward and provides a supporting structure **10, 10**.

FIGURE 6 shows a modified form of the fender in which the principal part **1** is a substantially rectangular parallelopiped having a central bore **14** with internal flat walls **16** and with two opposite outside faces **15** which are concave symmetrically inward about a transverse axis midway between the base and the buffer, and are substantially of semi-elliptical contour.

When the described fender structure is subjected to a ship's impact, this fender develops a deformation at first in its thinnest center portion **13** of the supporting rubber structure, just as would be developed in a circular fender, with the relation between the reaction and energy absorption being similar to that in a circular fender.

When the applied strain in this condition rises to account for about 50% of the total strain, the force of reaction sharply increases, reaching a certain value; thereafter with hardly any increase in the force of reaction, the strain alone increases, giving a large energy absorption. The later stage with this condition existing resembles the performance of a V-shaped fender, as heretofore used. In FIGURE 5, which illustrates in characteristic curves the relation between the applied load and the deflection against the fenders, curve A shows this relation for a circular fender, curve B shows the relation for a V-shaped fender as heretofore used, and curve C shows the relation for a novel fender according to the present invention.

As described above, the fender of this present invention combines the performances of both the known circular and the V-shaped fenders. That is, the reaction force vs. energy absorption relation of the fender of this present invention is that of a circular fender in the initial stage with 0–50% applied strain and that of a V-shaped fender in the later stage with 50–100% applied strain. The above mentioned characteristics would be highly effective for economical designing of the mooring facilities, because the low energy of mooring of frequent occurrence could be absorbed in the initial stage of 0–50% applied strain; and the reaction force being small, an economical section could be obtained even if designing structural members with an allowable stress under a long-term load; meanwhile, the high energy of mooring of less frequency could be absorbed in the later stage with 50–100% strain. The reaction in this state would be larger than that in the initial stage, but on account of its less frequency it might be regarded as a short-term load. Accordingly, up to a 50% increase over the allowable stress under a long-term load can be permitted as a stress developed in the cross section of the structural member of the fender.

Thus, adoption of a rubber fender of the design of this present invention will assure the construction of economical, highly safe mooring structures which can protect the outside plating of the hull surface from damage due to compression stress, and, with an ideal relation between reaction force and energy absorption, can have a proper balance between the ship's impact and the developed stress.

Moreover, the core plate **8** with longitudinal and transverse beams, being embedded in the buffer portion **5** of the main fender body, does not deflect and make it possible for the impact to be borne by the whole surface of the buffer.

The present invention provides an ideal fender with the constructions of the main body portion and the core plate of the buffer being as described.

I claim:

1. In a dock fender for absorbing the impact of a mooring ship, a principal part substantially of the shape of a rectangular parallelopiped and being provided with a central interior hollow space, a base at one end of said principal part formed integrally with said principal part, a buffer portion at the opposite end of said principal part formed integrally with said principal part, said principal part, said base and said buffer portion being formed of resilient material, the lateral portions of said principal part extending between said base and said buffer portion, having two inner opposite faces and two outer opposite faces and being of a non-uniform cross-section symmetrically about the plane midway between said base and said buffer portion, either two opposite faces comprising respectively arcs of an elliptical bore the long axis of which extends between said base and said buffer portion and the other two opposite faces being flat, and a reinforcing plate embedded in said buffer portion.

2. A fender according to claim **1**, wherein said reinforcing plate has an outwardly projecting grid-form consolidation of longitudinal beams and transverse beams, said grid-form consolidation being provided with protecting members.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

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