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(54) **Elastically active guiding system between structural bodies in relative movement**

(57) The present invention relates to a guiding system between structural bodies in relative movement, in particular structural bodies (1,2) of floating ships, which has co-axial guiding elements (6,7), preferably metallic, in which an element (5), or axialsymmetrical block made of an elastically active material, is inserted, and these coaxial guides are operatively coupled with sliding tracks each joined to a structural body (1) in relative movement with respect to the other (2) structural body of the tanker or natant in general.

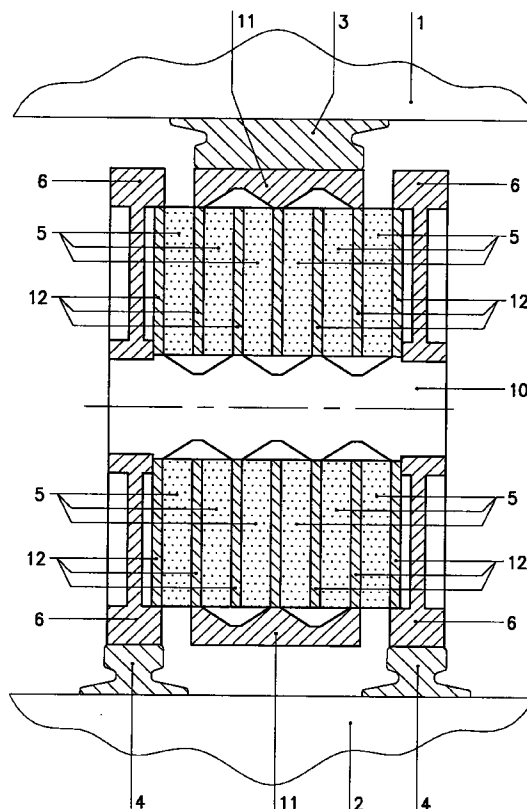


FIG.3

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Description

The present invention relates to a guiding system between structural bodies in relative movement, in particular between structural bodies subjected to relative rotations, preferably in floating plants in the open sea where a ship, firmly positioned, or sailing off-shore, is free to move around a towered structure, or various kinds of operating structures necessary for operations in the open sea.

More specifically, the guiding system is inserted in rotating supports of bodies with large dimensions, in particular for mooring towers and bodies of structures of floating means for the production of hydrocarbons. With reference to this field in the art, there is the problem of coupling two bodies moving in relative rotation, in particular bodies of large dimensional structures.

The technical problem deriving from the coupling of a natant and structural body, such as a tower, a launching device for positioning pipelines and other operating structures in floating plants in the open sea, is well known to experts in the field.

This natant can have any shape and dimension and will be simply called, using interchangeable terms, natant, or ship, or tanker, in the present description and claims.

It is known that a ship, or natant in general, must be free to move according to the weather-marine conditions to limit the stress inflicted by the actions of the wind and sea-waves. It is also known to experts in the field that operating structural bodies coupled with the ship must maintain a particular orientation with respect to a fixed reference, such as for example the sea-bottom. Floating plants are known, whose supporting structure and rotating guides of structural bodies having large dimensions such as cylindrical mooring towers, lifting cranes, pipe launching towers, or cables are at present accomplished by means of a combination of devices and units which create a rotating constraint by reacting to axial and/or radial forces and capsizing conditions. These applications of the known art have systems with rolls supported on a pivot of one of the structural bodies and resting on circular rails situated and fixed on the other structural body; they also have systems with sliding blocks connected to one of the structural bodies, often by means of elastic or hydraulic devices, which ensure uniform contact with circular tracks situated on the other structural body. A large number of the above systems, in relation to orientation with respect to the rotation axis of the supporting surfaces of the rolls, spheres or sliding blocks and means of relative contact, allows the transmission of axial and/or radial stress and capsizing conditions and altogether allows the rotating constraint desired. In the presence of structural bodies having considerable dimensions, the above systems of the known art create serious technical problems in the constructive tolerances conveniently produced and in the acceptable

structural deformations of the structural bodies in the part connected to the rotating support elements.

These factors, when rolls or spheres are used, result in a non-uniform distribution of the load among the rolling units, as only some of them are in contact, and consequently in a load concentration on only a part of them. This drawback alternatively requires an overdimensioning of these units, or the use of elastic or hydraulic devices which, in the presence of deformations of the sliding trails, allow almost constant loads on each element. These problems arise particularly in the rotating coupling of the mooring towers of floating production systems of hydrocarbons; the tower is a cylindrical body of large dimensions equipped with an axialsymmetrical structure having a relatively high rigidity which is housed, in most applications, in a cylindrical cavity of the ship, situated in its plane of symmetry; this cylindrical cavity is influenced by the stress conditions of the ship and the radial dimension and planarity of the supporting bases of the tower can vary even by several centrimetres, in relation to the maximum flexural stress to which it is subjected as a result of the undulating movement and load distribution on the ship.

Another characteristic of the ship-tower rotating coupling lies in the fact that most of the lower part of the tower, where the mooring cables are based and consequently where the constraining reactions of the anchor are applied, is normally immersed; in this area therefore it is not convenient, for reasons of functional reliability, to install preloading devices in the upper part of the tower to sustain horizontal loads even in the presence of deformations of the sliding bases of the support: in this area it is easy to carry out a control and maintenance and it is therefore possible to ensure the necessary operating reliability. This situation consequently makes it necessary to produce the rotating constraint of the tower in its upper part and it is therefore convenient and necessary for the constraint to be effected under capsizing conditions with a series of rolls or contrast sliding blocks which prevent the tower from lifting from the above supporting plane.

This known solution however creates a split and, in relation to the dimensions of the reaction arms used, an overdimensioning of the contact units to be produced. Systems which cause an active shifting, normally with hydraulic actuators, of the contact units, such as rolls or sliding blocks, require hydraulic plants which, owing to the operating reliability necessary and subdivision into sections, or groups of functional elements to be individually controlled in position, are considerably complex and costly and require continuous monitoring and maintenance to guarantee operating continuity.

These applications of the known art give rise to a series of constructive and operating drawbacks particularly when the stresses exchanged are high, when the structural deformability is considerable in at least one of the two bodies and also when there is sudden impact and pressure together with a chemically aggressive

marine environment.

There are also disadvantages deriving from the fact that in the case of interventions of maintenance or repair, the functioning of the whole operating structure must be interrupted. It is evident that the availability of a safe structural system for these operations in the sea requires operating structures with a high coefficient of annual use with obvious considerable economic advantages. In addition to these limitations, there are also, for the known applications, serious projectual restrictions which impose operating structural bodies of considerable dimensions and consequently substantial weight and also a high cost for the structures; the functioning of the known applications, moreover, has always proved to be often precarious and quite unreliable.

On the basis of various studies and lengthy experimentations, the applicant has set up an elastically active guiding system which has the purpose of eliminating the above disadvantages, by means of a structure consisting of mechanical elements which are easy to produce and with a safe and reliable functioning.

Another objective of the present invention relates to the absence of mechanically sealed units in relation to a chemically aggressive sea environment. These purposes are achieved by the guiding system between structural bodies in relative movement of the present invention, which consists of at least two substantially coaxial and interfacing guiding elements which form a single body with at least one inserted element made of an elastically active material, and the coaxial guides themselves which are coupled with at least two sliding tracks, of which at least one track is joined to a structural body and the other track to the other structural body and these sliding tracks face each other in an axially offset position.

In one embodiment, in this guiding system between structural bodies in relative movement, the element made of an elastically active material consists of a rubber disk, or made of an elastomeric material, fixed by vulcanization, or with similar methods, to the coaxial and interfacing guiding elements.

This guiding system between structural bodies in movement is also characterized in that the element made of an elastically active material is a single axialsymmetrical composite block of several alternating metallic disks and disks of an elastically active material. In one embodiment, this axialsymmetrical block made of an elastically active material is an axialsymmetrical hollow block subjected externally to force on the part of a rigid, suitably shaped, coupled circular gear and internally to a counterforce action on the part of a hub with a shape similar to that of the above circular gear, but with axially offset profiles with respect to each other to allow operating elastic deformation to compensate the relative movements of the functionally associated structural bodies. In an embodiment, these coaxial guiding elements and sliding tracks of the guiding system of the present invention are made of metal or a rigid polymeric

material with a high resistance to specific pressure.

The invention is described in detail hereunder and on the basis of the example schematically represented in the drawings of the figures of the enclosed tables, which briefly illustrate the characteristics of the invention. It should be pointed out that all the enclosed drawings and the description thereof, correspond to a preferred form of enforcement for a better understanding of its embodiment, however any constructive variations included in the general idea which is illustrated in the enclosed drawings should be considered as forming part of the patent protection.

- figure 1 is a schematic view of the front section of the guiding system of the present invention with two coaxial interfacing guiding elements in which a disk made of an elastically active material is inserted and with two sliding tracks each coupled and fixed to a structural body in relative movement, and this view also illustrates with dashed lines the presence of successive repeatable elements analogous in shape and function to the previous ones;
- figure 2 is a schematic view of the front section analogous to figure 1 but with a structural elastic deformability upon actions of great stress generated by the relative movement of the interfacing and operatively coupled structural bodies;
- figure 3 is a schematic view of the front section of the guiding system of the present invention with the element made of an elastically active material consisting of a hollow axialsymmetrical block coupled externally by a rigid circular gear advantageously shaped and internally with a hub, which has a profile analogous to the external gear but axially offset to allow the elastic deformation of the hollow block when subjected to considerable stress generated by the relative movement of the structural bodies operatively connected;
- figure 4 is a schematic view of the front section analogous to figure 3 but with a structural elastic deformability of the hollow axialsymmetrical block upon the force generated by the relative movement of the interfacing and operatively connected structural bodies and this view also illustrates the deformation of the block profile which conforms with the rigid profiles of both the external gear and the internal hub.

In the figures, the same parts, or parts with the same functions, have the same references. Also in the figures, for the purpose of simplicity, the parts which are not necessary for understanding the invention are omitted or are illustrated in a general form in that they are already known and also because they do not relate to the functioning of the present invention.

With reference to the above figures, the guiding system between the structural bodies 1 and 2 in relative movement according to arrows 8 and 9 comprise guid-

ing elements 6 and 7, preferably steel metal disks, which are coupled with the sliding tracks 3 and 4; the latter are preferably in the form of steel metal rails. More specifically, rail 3 is joined, as a single body, to the structural body 1, whereas rail 4 is joined, as a single body, to the structural body 2. These guiding disks 6 and 7 face each other and are joined by disk 5 made of an elastically active material, preferably rubber fixed by vulcanization to the metal guiding disks 6 and 7.

In a concrete embodiment the rubber disk 5 is in the form, advantageous for sudden forceful thrusts, of a hollow axialsymmetrical block in which there are alternating rubber disks 5 and metal, preferably steel, disks 12. The block becomes a single body between the rubber disks 5 and the steel disks 12, by means of a vulcanization process, and is externally coupled with the circular geared guide 11, which operatively acts on rail 3, and is also internally coupled with the hub 10, advantageously shaped and preferably made of steel. More specifically, the profile of the circular gear 11 has basically the same size and shape as the profile of the device 10 but these profiles are axially offset by half a pitch to allow elastic deformability upon thrusts activated by the relative movement of the structural bodies 1 and 2, as is clearly illustrated in figure 4.

The assembly, functioning and dynamic behaviour of the elastically active guiding system of the present invention, are clearly illustrated in the figures of the enclosed tables. When the elastically guiding system is in rest position, it corresponds to figure 1 and the elastic disk 5 is not deformed and therefore not subjected to shear stress, and it is substantially coaxial with the guiding disks 6 and 7. More specifically, reference is preferably made to the specific case of the constraint of a cylindrical tower 2 with the ship 1 for mooring in the open sea and process connection in a floating production system, but this solution can be advantageously applied in all cases of rotating and/or transferring constraint between large dimensional bodies when there are inevitable constructive defects, owing to the difficulty in obtaining small tolerances in the coupling between the guiding disks 6 and 7 and the sliding tracks 4 and 3, and when there are inevitable structural deformations of at least one of the structural bodies 1 and 2, and therefore of the rails 4 and 3 connected to them, induced by the functioning of the structure of the bodies 1 and 2, or for any other reason, for example differential thermal expansion, etc.

When the structural bodies 1 and 2 move, according to arrows 8 and 9, the rubber disk 5, subjected to shear stress, becomes deformed and assumes the sloping configuration of figure 2. At the end of the relative movement between the bodies 1 and 2, the elastic disk 5 returns to the rest configuration of figure 1. Analogously for a greater degree of stress, the elastically active axialsymmetrical block will assume the rest position corresponding to figure 3 when no relative movement is transmitted between the structural bodies 1 and

2. In the presence of structural deformability caused by considerable sudden thrusts, the bodies 1 and 2 move according to arrows 8 and 9 and the elastic block, consisting of the elements 5 and 12 alternatively joined to each other, assumes the configuration of figure 4. Each rubber disk 5 assumes a sloping configuration, as it is subjected to shear stress and its relative deformation is not hindered as it adapts itself to the profiles appropriately produced and positioned on the internal surface of the rigid circular gear 11 and on the external surface of the steel hub 10.

The elastically active guiding system between structural bodies 1 and 2 in relative movement thus conceived is susceptible to numerous modifications and variations which are all included in the scope of the present invention. In practice, the elements illustrated can be substituted with other technically equivalent elements and still remain within the scope of the present invention.

Claims

1. A guiding system between structural bodies in relative movement, in particular between structural bodies operating on ships floating in the open sea, characterized in that it comprises at least two substantially coaxial and interfacing guiding elements which form a single body with at least one inserted element made of an elastically active material, and the coaxial guides themselves are coupled with at least two sliding tracks, of which at least one track is joined to a structural body and the other track to the other structural body and these sliding tracks face each other in an axially offset position.
2. The guiding system between structural bodies in relative movement according to claim 1, characterized in that the element made of an elastically active material inserted between the coaxial facing guiding elements, is a disk made of rubber, or an elastomeric material, fixed by vulcanization, or other similar methods, to the same coaxial and frontally interfacing guiding elements.
3. The guiding system between structural bodies in relative movement according to claims 1 and 2, characterized in that the element made of an elastically active material inserted between the coaxial interfacing guiding elements is an axialsymmetrical block consisting of a single body of several alternating metallic disks and disks of an elastically active material.
4. The guiding system between structural bodies in relative movement according to claims 2 and 3, characterized in that the composite axialsymmetrical block having a single body of several alternating metallic disks and disks of an elastically active

material, is an axialsymmetrical hollow block subjected externally to force on the part of a rigid, suitably shaped, coupled circular gear and internally to a counterforce action on the part of a hub with a shape basically similar to that of the above circular gear, but with axially offset profiles with respect to each other to allow operating elastic deformability to compensate the relative movements of the functionally associated structural bodies.

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5. The guiding system between structural bodies in relative movement according to claim 1, characterized in that the coaxial guiding elements and the coupled sliding tracks are made of a metallic material, or a rigid polymeric material with a high resistance to specific pressure.

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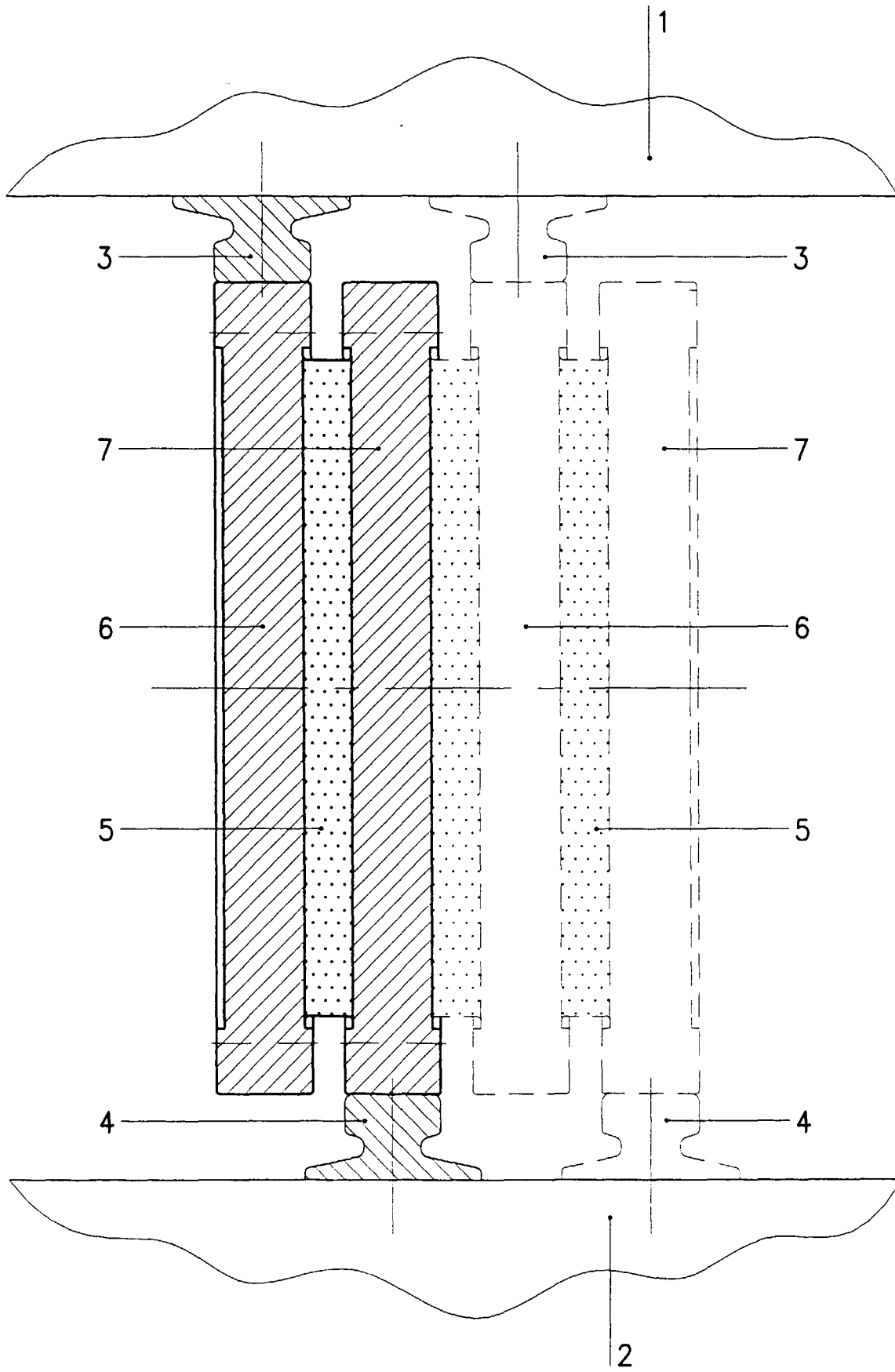


FIG. 1

