

PATENT SPECIFICATION

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(54) FLUID LOADING DEVICE

(71) We, NIGATA ENGINEERING CO., LTD., a Japanese Company, of No. 27-7, Taito 2-chome, Taito-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fluid loading devices and more particularly to a balancing mechanism for a loading arm used for loading crude oil or the like onto a tanker subject to rolling and pitching.

Crude oil, petroleum distillates or like fluid are loaded onto a tanker by means of fluid loading devices which can readily follow the movement of the ship due to wave action and take into consideration the natural rolling and pitching of the tanker as a result thereof. Such fluid loading devices permit connection and disassembly to the fluid manifold of a marine vessel such as a tanker, to be effected easily and simply, and such devices are generally simple in construction, easy to maintain and easy to inspect, etc. Two representative examples of such fluid loading devices are explained with reference to the first two figures of the drawings (see below).

Fig. 1 shows an example of a known liquid loading device making use of wire cable. The device comprises an inner hollow arm 1 being pivotably coupled to an outer hollow arm 2 by way of a sheave 11a which is rotatable with arm 2 and mounted for rotation on arm 1. The inner hollow arm 1 is provided with an inner balancing arm 3 which may in fact be an extension thereof, the inner hollow arm 1 being mounted for rotation about a horizontal axis at the upper end of a fixed, vertical hollow supporting member 7, which extends vertically upward and is connected to a source of liquid (not shown). The hollow supporting member 7 supports the inner hollow arm 1 for rotation about both vertical and horizontal axes by a hollow swivel joint

8. A hollow swivel joint 9 couples the outer hollow arm 2 to the hollow arm 1 and permits the outer hollow arm 2 to rotate about a horizontal axis extending through the hollow swivel joint 9. A hollow swivel joint connection at 10 at the outer end of the outer hollow arm 2 permits the liquid loading device to be coupled to a tanker manifold (not shown). Balancing weights 5 and 6 are carried by the inner balancing arm 3, weight 5 being concentrically mounted to the outer end of the inner balancing arm 3 beyond a sheave 12a. The sheave 12a is mounted for pivoting about a horizontal axis extending through the inner balancing arm 3 and at right angles to the longitudinal axis of that arm. A balancing weight 6 is fixed to the sheave 12a by way of an outer balancing arm 4 which acts as a radial extension of the sheave 12a. Thus, the weight 6 rotates at the outer end of the balancing arm 4 about the horizontal axis extending through the sheave 12a. The rotation of the sheave 12a is controlled by the rotation of the sheave 11a which in turn is controlled by movement of the outer hollow arm 2 relative to the inner hollow arm 1. Connection between the sheaves is achieved by wire cables 13a and 13b joined by means of fixing members 13c and 13d to form an endless wire cable loop trained about the sheaves 11a and 12a. The fixing members 13c and 13d fix the corresponding points on the wire cables 13a and 13b relatively to the sheaves 11a and 12a so that the sheaves rotate together.

In this construction, when the hollow swivel joint 10 connected to a manifold of a tanker (not shown) is moved with respect to the hollow supporting member 7, due to rolling and pitching of the tanker, the balancing weight 6 is moved, together with the outer balancing arm 4, by the movement of the sheaves 11a, 12a and the wire cables 13a, 13b, to establish a weight balancing relationship in terms of the equation:

$$W_o(R_o \sin \theta_1 + L_i \sin \theta_2) + W_i(R_i \sin \theta_2) - W_{ci}(R_{ci} \sin \theta_2) - W_{co}(L_c \sin \theta_2 + R_{co} \sin \theta_2) = 0$$

where

W_o =weight of outer hollow arm 2, hollow swivel joint 10, etc.,

W_i =weight of inner hollow arm 1, sheaves 11a, 12a, inner balancing arm 3, etc.,

W_{co} =weight of balancing weight 6, outer balancing arm 4, etc.,

W_{ci} =weight of balancing weight 5 etc.,

R_o =distance between the pivot axis of outer hollow arm 2 to the gravitational centre of W_o ,

L_i =length of inner hollow arm,

L_c =centre distance between the pivot axis for the hollow swivel joint 8 and that of sheave 12a,

R_i =distance from the pivot axis of the hollow swivel joint 8 to the gravitational centre of W_i ,

R_{ci} =distance from the swivel joint 8 to the gravitational centre of W_{ci} ,

R_{co} =distance from the pivot axis of sheave 12a and outer balancing arm 4 to the gravitational centre of W_{co} .

The construction illustrated in Fig. 1 is such that an equilibrium is maintained by satisfying the relationship $\theta_1 = \theta_2$.

The advantage of this known device is that since the maximum angle included between the inner hollow arm 1 and the outer hollow arm 2 is 180° , a wider operating range of the loading arm is obtained. On the other hand, it has a disadvantage that an elongation is produced in the wire cable array when it is loaded, causing difficulty in maintaining equilibrium, and that it requires maintenance such as periodic coating with an anti-corrosive material, etc. As an alternative to the construction of Fig. 1, such devices may be constructed employing sprocket wheels instead of sheaves 11a, 12a and endless chains instead of the wire cables 13a, 13b, but the elongation due to wear and the disadvantageous maintenance such as periodic coating with an anti-corrosive material, etc. are not materially reduced.

Fig. 2 shows a second example of a known fluid loading device using, instead of the cable array and sheaves, a single connecting rod forming a parallelogram linkage. Parts corresponding to those shown in Fig. 1 are given like reference numerals. Thus, the parts designated by numerals 1-10 and the construction thereof are substantially the same as that shown in Fig. 1. In Fig. 2, an arm 11b which is rotatably mounted to follow the rotation of the outer hollow arm 2 relative to the inner hollow arm 1, has pivotably connected thereto, at one end, a single connecting rod 13e which in turn is pivoted to the outer end of a balancing arm 4 and which constitutes a link parallel to the inner hollow arm 1. It is so arranged that equilibrium is maintained as in the case of Fig. 1 by movement of the balancing weight 6

coupled also to the outer end of arm 4 by the connection through the connecting rod 13e, and arm 11b follows movement of the hollow outer arm 2.

In the device of Fig. 2, maintenance and inspection may be effected more easily as compared with the wire and cable arrangement of the device shown in Fig. 1. On the other hand, it is necessary to maintain the maximum included angle within a given limit in order to restrict the load applied to the connecting rod 13e. Furthermore, when the outer hollow arm 2 is retracted inwardly, as shown by the double dotted broken line in Fig. 2, a large compressive force acts on the connecting rod 13e which operates to balance the rotational force on the outer hollow arm 2 and the outer balancing arm 4 due to their own weights, so that a further drawback occurs in that it is necessary to provide a connecting rod 13e with a relatively large cross sectional area to provide the necessary buckling strength to resist the compressive force acting thereon.

The present invention provides a fluid loading device of the type including an upwardly extending hollow supporting member having at its upper end an inner hollow arm pivoted for rotation about a first, generally horizontal axis, and said inner arm in turn having pivotably supported at a free end thereof, an outer hollow arm for rotation about a second generally horizontal axis, said device further comprising

a first polygonal cam plate mounted to said outer hollow arm for rotation together therewith about said second axis and

a second similar polygonal cam plate mounted for free pivoting movement about an axis parallel to said second axis and fixed with respect to said inner arm,

a balancing weight mounted to said second polygonal cam plate radially outward of its pivot axis and in a circumferential position related to the circumferential position of said outer hollow arm relative to said first polygonal cam plate, and

an endless loop of linked rods trained about said cam plates for causing said plates to rotate together, said rods each having a length equal to $1/n$ times the length of one side of the polygonal cam plates, where n is an integer.

The invention is illustrated by way of example in the accompanying drawings, in which:

Fig. 1 (referred to above) is a schematic, front view of a conventional fluid loading device.

Fig. 2 (referred to above) is a front view of another conventional fluid loading device.

Fig. 3 is a front view of a fluid loading device in accordance with one embodiment of

the present invention, the arms in the same positions as in the case of the device shown in Fig. 1.

Fig. 4 is a front view of the fluid loading device of Fig. 3, with the hollow arm pivoted to a horizontal position.

Fig. 5 is a plan view of the device shown in Fig. 4.

Fig. 6 is a sectional view of a portion of the device shown in Fig. 3 taken on line 6-6 of Fig. 3.

With reference to Figs. 3-6, parts of the fluid loading device of the present invention which are common to the devices of Figs. 1 and 2 bear like reference numerals. In this respect, numeral 1 designates the inner hollow arm; 2 the outer hollow arm; 3 the inner balancing arm; 4 an outer balancing arm; 5 and 6 balancing weights; and 7 a fixed hollow supporting member extending vertically upward from a wharf (not shown). The numerals 8, 9 and 10 designate hollow swivel joints as also described above. The hollow swivel joints 8, 9 and 10 allow free rotation of the inner hollow arm 1 in a vertical and horizontal direction relatively to the hollow supporting member 7 which extends vertically upwards, of the outer hollow arm 2 in a vertical direction relative to the inner hollow arm 1 and about a horizontal axis, and of the outer hollow arm 2 in vertical and horizontal directions relative to the manifold (not shown) of a tanker or the like to which the device is connected by way of the swivel joint 10. The construction of the swivel joints is the same as the swivel joints in the conventional devices illustrated in Figs. 1 and 2.

A cam plate 11 which is polygonal in plan configuration is secured to the outer hollow arm 2, and a cam plate 12 of similar configuration is supported for rotation about a horizontal axis at a point on the inner balancing arm 3 between the weight 5 and the horizontal pivot axis of the hollow swivel joint 8. A series of small rods 13f are linked together to define an endless loop as at 13 with the linked connecting rods being trained about the respective cam plates 11 and 12, such that pivoting of the outer hollow arm 2 about a horizontal axis defined by the swivel joint 9 causes the cam plate 11 to pivot about the same axis, and by way of linked rods 13f transmits a corresponding rotation of the polygonal cam plate 12 about a horizontal pivot axis on the inner balancing arm 3. Turnbuckles 14a and 14b permit tensioning of the loop of linked rods 13f. The connecting rod loop 13 interlocks the operations of the outer hollow arm 2 and the outer balancing arm 4 and maintains a substantial weight equilibrium therebetween.

The hollow supporting member 7 is connected to a liquid transfer pipe (not shown) at the pier or wharf and the hollow swivel

joint 10 is connected to a manifold (not shown) of a tanker or the like. In this condition, the tanker is connected to the liquid transferring pipe at the pier or wharf through the hollow swivel joints 8, 9 and 10, the outer hollow arm 2, the inner hollow arm 1 and the hollow supporting member 7, whereby the transfer of liquid can be effected regardless of pitch or other movement of the tanker. During this time, even when the tanker is moved vertically or horizontally due to the variation in total load and changes in inclination due to wave action or tide action, the balance of the dead weight of the loading arm is maintained by means of the balance weights 5 and 6. Only a frictional force caused by rotation of the hollow swivel joints 8, 9 and 10 and other small resistive forces act on the manifold of the tanker, so that the loading arm can easily follow the movement of the tanker and thus a safe loading operation can be effectively carried out.

The advantages of the liquid loading device constructed as described above are as follows: The first advantage is that with the construction of the connecting rod loop 13, formed by training the loop of linked rods over the cam plates 11 and 12, each of which has a tetragonal shape, only tension acts on the connecting rods so that there is no danger of buckling and the mass of the parts can therefore be reduced. While it is preferable that the cam plates 11 and 12 each have a tetragonal shape, the shape is limited to a polygon, and the plates may take the shape of a pentagon or hexagon if desired. In the second place, it is possible to obtain a maximum reach by controlling the maximum included angle between the inner hollow arm 1 and the outer hollow arm 2 to 180° using the linked rods 13f. Thirdly, in a broad sense, although a plurality of small rods 13f constituting the connecting rod loop 13, may be at first glance thought to be a modification of a power transmitting chain, by utilizing a tetragonal cam plate arrangement, chain sprocket wheels are not necessary, and a smooth transmission of rotary motion can be very practically obtained, serving as a balancing device for the loading arm, without requiring means corresponding to the braking means normally employed where a wire cable is used. In short, the present fluid loading device makes maximum advantage of the conventional wire cable system and the single interlocking rod system and compensates for the disadvantages of both, whereby the rotating range can be increased, the maintenance and inspection may be effected more easily, and an excellent, easily operable, fluid loading device is the result.

Furthermore, the cam plate 12 is not limited in terms of its being pivoted on the interbalancing arm 3, but it also may be pivotably mounted at the hollow swivel joint

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- 8, for rotation about a common horizontal axis. In this case, the weight of the balancing weight 6 is determined by placing within the equation, $L_c=0$. It is possible, theoretically, to combine two or more small rods 13f for a single side of the cam plate by setting the length of the small rod 13f at a value of $1/n$ times the side length of the cam plate, where n is an integer.
- 10 While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:—

- 20 1. A fluid loading device of the type including an upwardly extending hollow supporting member having at its upper end an inner hollow arm pivoted for rotation about a first, generally horizontal axis, and said inner arm in turn having pivotably supported at a free end thereof an outer hollow arm for rotation about a second generally horizontal axis, said device further comprising
- 25 a first polygonal cam plate mounted to said outer hollow arm for rotation together therewith about said second axis and
- 30 a second similar polygonal cam plate

mounted for free pivoting movement about an axis parallel to said second axis and fixed with respect to said inner arm,

a balancing weight mounted to said second polygonal cam plate radially outward of its pivot axis and in a circumferential position related to the circumferential position of said outer hollow arm relative to said first polygonal cam plate, and

40 an endless loop of linked rods trained about said cam plates for causing said plates to rotate together, said rods each having a length equal to $1/n$ times the length of one side of the polygonal cam plates, wherein n is an integer.

2. A fluid loading device as claimed in claim 1, wherein said rods each have a length equal to the length of one side of the polygonal cam plates.

3. A fluid loading device substantially as described herein with reference to Figs. 3—6 of the accompanying drawings.

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