United States Patent [19]

Brown, deceased et al.

[11] **3,921,815**

[45] **Nov. 25, 1975**

[54] **CRANE WITH A SUSPENDED ROTATABLE COUNTERBALANCE**

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[52] **U.S. Cl.** **212/3;** 212/48; 114/5

[51] **Int. Cl.²** **B66C 13/16;** B66C 23/72

[58] **Field of Search** 212/3, 47–49; 9/34; 114/5, 44, 121

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Primary Examiner—Robert J. Spar
Assistant Examiner—R. B. Johnson

[57] **ABSTRACT**

A machinery deck of a counterbalancing crane is rotatably mounted on a vertical axis on an upstanding pedestal in an offshore location. An upwardly directed boom and an upwardly directed mast are pivotally mounted with respect to a forward portion of this deck for movement in a vertical plane passing through the axis of rotation of the deck with respect to the pedestal. A counterweight tank filled with sea water is pinned to the underside of a rearward portion of the deck intermediate the outermost end of the rear portion and the vertical axis of deck rotation. Counterweight support wheels are rotatably mounted on vertical axes with respect to a bottom portion of the counterweight; and a cylindrical counterweight support collar is supported on the pedestal in concentric relation to the axis of deck rotation and in position to receive counterweight wheels. A suspension between an upper part of the mast and an upper part of the boom and a suspension between the counterweight and an upper part of the mast permits the counterweight to act in a counterbalancing mode with respect to a load suspended from a load line supported from the point of the boom. A bearing platform is provided by the counterweight to be in underlying relation to the outermost rear end portion of the machinery deck so that as the entire counterbalancing effect of the counterweight has been utilized and a counterweight tends to lift its wheels away from the counterweight support collar, the upward force on it is transmitted through this bearing platform to the outermost rear end portion of the machinery deck.

16 Claims, 3 Drawing Figures

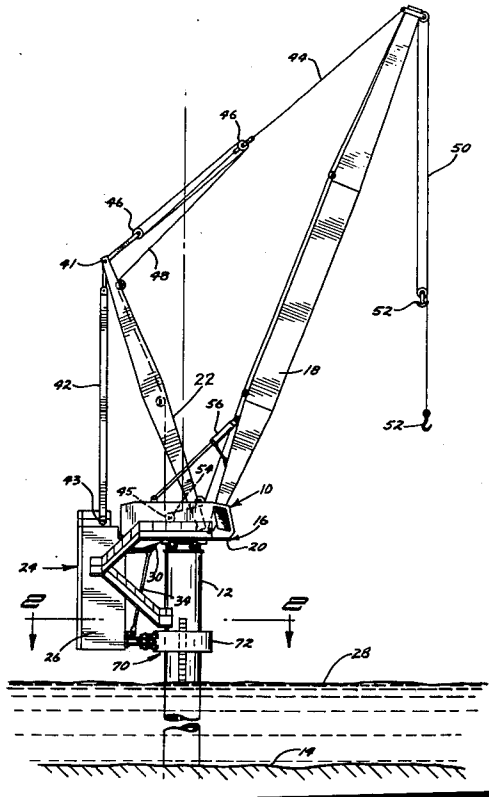
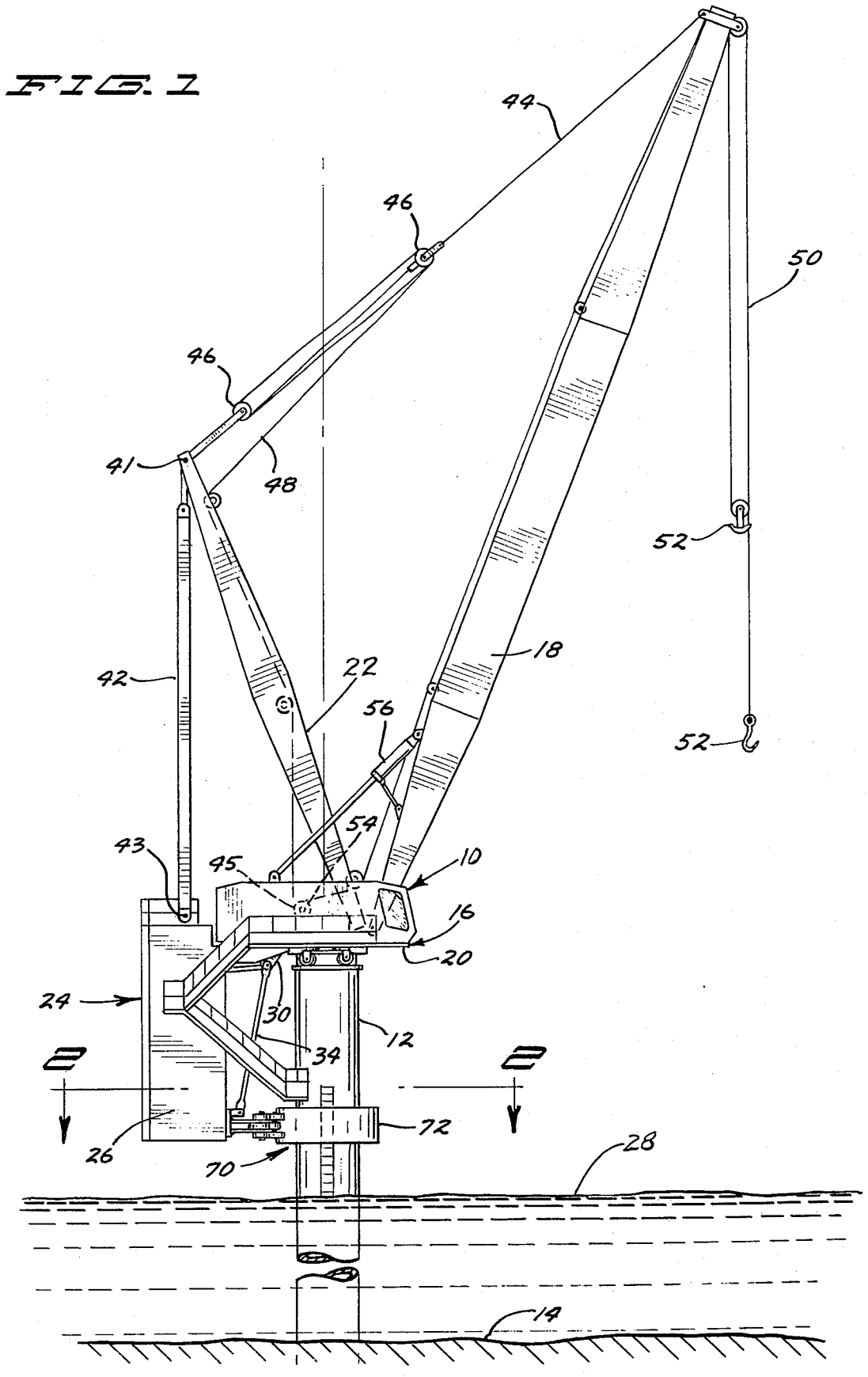


FIG. 1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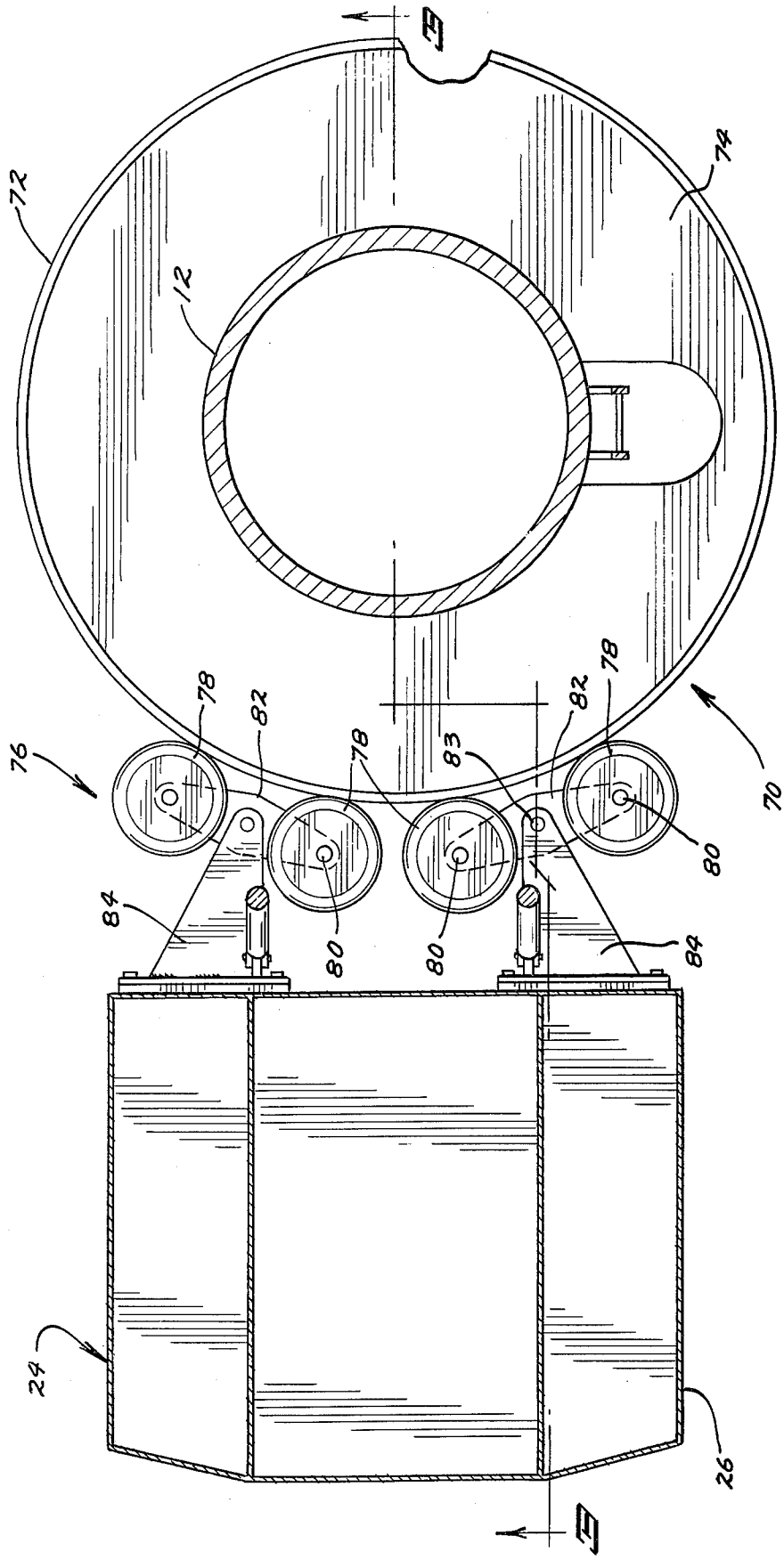

FIG. 2

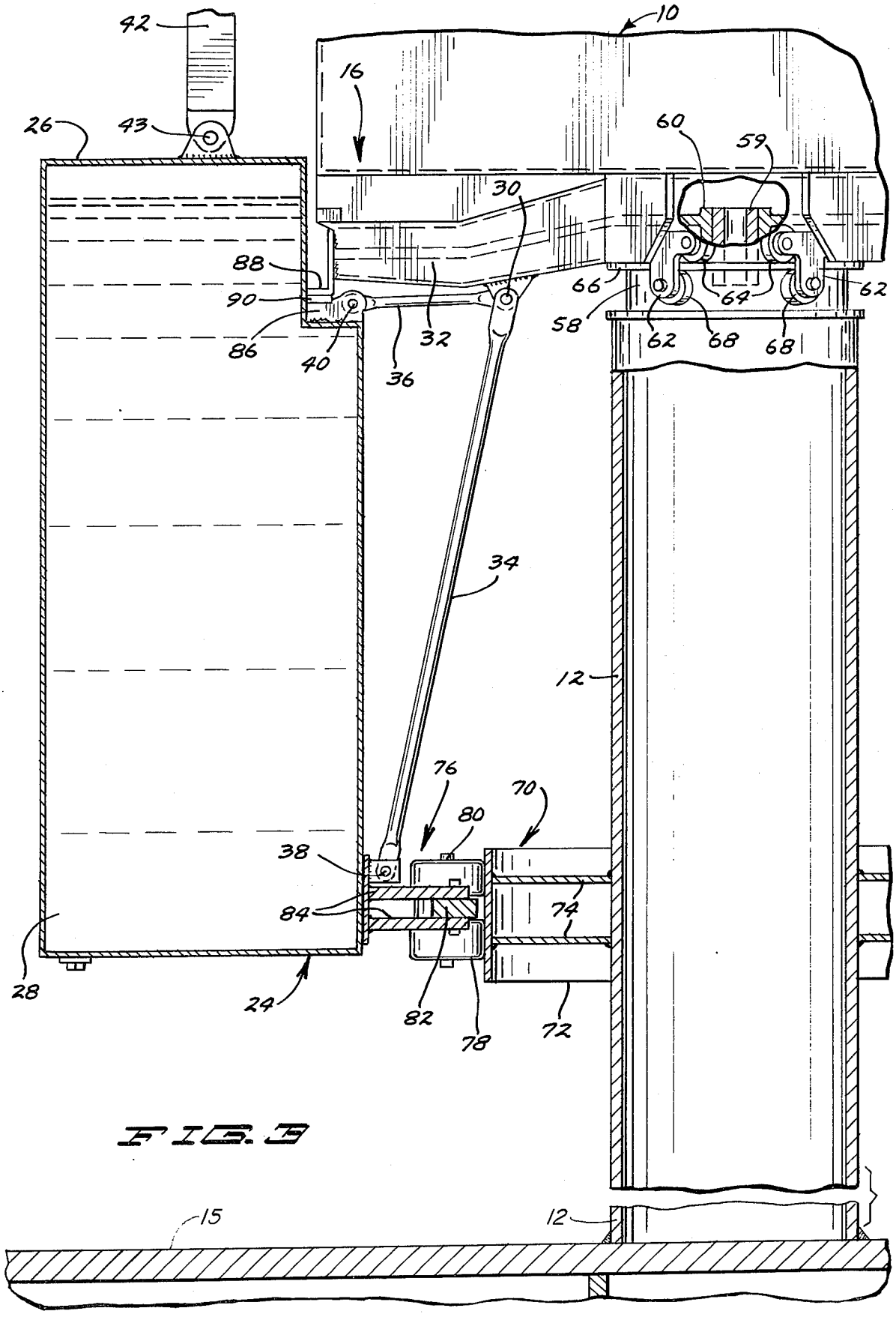
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FIG. 3

CRANE WITH A SUSPENDED ROTATABLE COUNTERBALANCE

BACKGROUND OF THE INVENTION

This invention has relation to counterbalancing cranes of the pedestal type. Such cranes are used for handling cargo from seagoing vessels to floating platforms or to fixed platforms mounted on the sea bottom. They find particular usefulness in offshore oil drilling operations, for example.

It is now well known to support a counterweight on a horizontal supporting surface behind a rearward portion of a rotatable machinery deck in such a manner as to have the counterbalancing effect of the counterweight when needed in handling heavy loads. See application of Archer W. Brown et al., filed Dec. 11, 1972, for CRANE COUNTERBALANCING TRAILER ASSEMBLY, now U.S. **3,842,984;** No. 3,842,984 a continuation-in-part of application Ser. No. 102,500, filed Dec. 29, 1970; which was a continuation of Application Ser. No. 767,670, originally filed Oct. 15, 1968, now abandoned. See also U.S. Pat. No. 3,485,383.

In the Archer Brown patent, downward stress on the machinery deck by the counterweight is completely avoided by attaching the counterweight to the machinery deck to rotate with the deck, but by supporting it on wheels running on a relatively flat horizontal surface on which the crane carbody is supported. However, in order to utilize the weight of the rearward portion of the machinery deck as additional counterweight at the point when the counterweight is no longer relying on the ground for its support, it is necessary to critically control the relationship between the mast to counterweight suspension and the mast to machinery deck suspension. Only in this manner does the outermost rearward end of the machinery deck become available to counterbalance the load on the boom as the counterweight is lifted from the supporting surface.

Neither the horizontal supporting surface as shown in the Archer Brown patent nor the ring as shown in U.S. Pat. No. 3,485,383 are available for use with pedestal mounted cranes of the general type as disclosed in U.S. Pat. No. 2,703,180, for example. This is because no economically feasible, effective means of providing a horizontal support surface for the counterweight is available without introducing destructive or at least unsafe torque forces in the pedestal.

However, it is desirable in such pedestal mounted cranes to provide counterweight support for handling very heavy loads while not unduly stressing the machinery deck and the pivotal mounting connections between the machinery deck and the pedestal when such heavy loads are not being handled.

SUMMARY OF THE INVENTION

A machinery deck of a counterbalancing crane is rotatably mounted with respect to an upstanding pedestal or other support. This support can be a pedestal fixed to the sea floor or to a floating barge in an offshore location; or can be a carbody or the like temporarily or permanently fixed to the ground. An upwardly directed boom and an upwardly directed mast are pivotally mounted with respect to a forward portion of this machinery deck for movement in a vertical plane passing through the axis of rotation of the deck with respect to the support. A counterweight is pivotally mounted with respect to the deck on a horizontal axis perpendicular

to this vertical plane, in such a manner that rotation of the deck on its vertical axis will cause rotation of the counterweight about the same vertical axis. A first suspension means connects an upper portion of the mast with an upper portion of the boom, a second suspension means connects the counterweight with an upper portion of the mast, a load line extends over the point of the boom to connect to a load handling device, means is provided for rotating the deck, and means is provided for spooling the load line.

A counterweight load bearing entity is provided with a counterweight load bearing surface, and counterweight support means are provided for supporting a portion of the counterweight in load bearing relationship to such load bearing surface when the load line, the mast, the boom, the first suspension means and the second suspension means are not supporting a maximum load. Said counterweight support means is such as to permit the counterweight to rotate horizontally with the deck and with respect to said pedestal or other support. Cooperating bearing means are provided between the counterweight and a rearward end portion of the machinery deck for transmitting upward forces on the counterweight to said rear end portion of said deck when the load on said load line causes the second suspension means to lift the weight of the counterweight from the counterweight supporting entity.

In the form of the invention as shown, the counterweight load bearing entity is constituted as a cylindrical, horizontally disposed, counterweight support collar mounted on a pedestal to be concentric with the axis of machinery deck rotation; and the counterweight support means includes wheels rotatably mounted on vertical axes with respect to a lower portion of the counterweight. The cooperating bearing means includes a bearing platform constituted as an integral part of the counterweight in underlying vertically aligned relationship to an integral outermost rearward end portion of the machinery deck. Also as disclosed herein, shims are provided between this outermost portion of the deck and the counterweight bearing platform so that any upward movement of the counterweight will be immediately transmitted to the rearward end portion of the deck. The point of pivotal mounting of the counterweight with respect to the deck, in the form of the invention as shown, is located between the vertical axis of rotation of the deck with respect to the pedestal and the outermost rearward end portion of the deck.

As shown, the counterweight is constituted as a hollow tank which can be filled with sea water, for example.

In the drawings:

FIG. **1** is a side elevational view of an offshore counterbalancing crane of the invention showing a pedestal mounted to this sea floor;

FIG. **2** is an enlarged horizontal sectional view taken generally on the line **2—2** in FIG. **1**; and

FIG. **3** is a fragmentary vertical sectional view taken generally on the line **3—3** in FIG. **2** and at a somewhat reduced scale but showing the pedestal mounted on a floating barge.

DESCRIPTION OF PREFERRED EMBODIMENT

An offshore counterbalancing crane **10** includes a cylindrical pedestal **12** permanently fixedly mounted in the sea floor **14** on a floating barge **15,** in any usual or preferred manner, and a machinery deck **16** rotatably

mounted on the pedestal **12**.

A boom **18** is pivotally mounted to a forward portion **20** of the machinery deck **16**, as is a mast **22**.

A counterweight **24** includes a counterweight tank **26** filled, for example, with sea water **28**. This counterweight is pivotally mounted or pinned as at **30** to a rearward portion **32** of the machinery deck **16** through the instrumentality of a downwardly extending strut **34** and a generally horizontally extending strut **36**. These struts are pinned to the counterweight at **38** and **40** respectively.

A first linkage or suspension **44** is connected between the tip of the mast **22** and the point of the boom **18**. As shown, this first suspension is adjustable in length by operating appropriate machinery **45** on the machinery deck **16**, to lengthen and shorten the distance between the sheaves **46, 46** due to lengthening and shortening of first suspension control line **48**. A second linkage or suspension **42** is connected between an upper portion of the counterweight tank **26** as at **43**, and the top of the mast **22** as at **41**. A load line, or load lines **50** pass over a sheave at the point of the boom **18** and are connected to load handling devices such as load hooks **52**. Machinery **54** is provided, on the machinery deck as shown, for controlling the length of the load lines. Machinery **45** and **54** can be of any usual or preferred construction and can be located at any convenient place just so long as the control line **48** passes to the sheaves **46** and the load line **50** passes over the boom point.

A shock absorbing boom stop **56** is pivotally mounted to the machinery deck and to the boom **18** to prevent movement of the boom to a position where it would have a tendency to fall toward the rearward portion of the machinery deck.

The rotatable mounting of the machinery deck **16** to the pedestal **12** can be accomplished, as best seen in FIG. **3**, by providing a combination bull gear and roller path **58** as the top cap of the pedestal. A bull gear center pin **59** extends integrally upwardly therefrom. A bull gear center pin bushing **60** fits over pin **59** and is constituted as an integral part of machinery deck structure, as are load roller and hook roller brackets **62, 62**. Load rollers **64** are rotatably mounted on the brackets **62** to support the machinery deck on a roller path flange **66** of the combination bull gear and roller path **58**. Hook rollers **68** are rotatably mounted on these brackets **62**, run on the bottom side of flange **66**, and serve to resist any upward forces exerted by the machinery deck on the flange. Other equally suitable means of rotatably mounting the deck to the pedestal could be employed without departing from the spirit or scope of the invention.

A counterweight load bearing entity **70** includes, in the form of the invention as shown, a cylindrical counterweight support collar **72** integrally supported on the cylindrical pedestal **12** in concentric relationship to it and to the vertical axis of the bull gear and roller path **58** as by horizontally outwardly extending plates or flanges **74, 74**.

Counterweight support means **76** includes counterweight support wheels **78** each rotatably mounted on a vertically disposed axle **80** which, in turn, are supported in horizontally disposed wheel beams **82**. These wheel beams are pivotally mounted as at **83** to counterweight wheel brackets **84** which are integral with and extend outwardly from a lower portion of counterweight tank **26**.

Counterweight tank **26** is also provided with a bearing platform **86** which is in vertical alignment immediately under an outermost rearward end deck bracket **88** integral with the outermost end of the rearward portion **32** of machinery deck **16**. With the parts positioned as seen in FIGS. **1** and **3**, one or more metallic shims **90** are situated between and in contact with the platform **86** and the bracket **88** to insure that any upward movement whatever of counterweight tank **26**, and consequently bearing platform **86**, is directly transmitted to the outermost end of the rearward portion **32** of the machinery deck **16** through the bracket **88**.

OPERATION

With the parts of the counterbalancing crane positioned as seen in FIG. **1**, no working load is present on the load hooks **52**, so the upward force exerted by second suspension **42** on the counterweight **24** will be at a minimum. In this configuration, the counterweight **24** is supported on the machinery deck entirely by struts **34** and **36** and by the pivotal mounting at **30** of those struts to the underside of the rearward portion of the machinery deck **16**. Being free to pivot about the pin **30**, and with no other connection to the machinery deck **16**, a considerable force is exerted by a lower portion of the counterweight and through the counterweight support wheels **78** onto the cylindrical counterweight support collar **72**. This causes an equal and opposite shear force to be exerted by the bull gear center pin bushing **60** on the bull gear center pin **59**, fixedly positioned, as it is, with respect to the pedestal **12**, in the form of the invention as shown.

As is usual in structures of this kind, a drive pinion, downwardly extending from the machinery deck **16** into the interior of the bull gear **58**, meshes with this bull gear. To rotate the machinery deck with respect to the pedestal, power means are provided to turn the pinion on its axis, thus to cause the machinery deck **16** to rotate relative to the bull gear and roller path combination **58**. Means for rotating the machinery deck with respect to the pedestal are not specifically shown, as this can be accomplished in any usual or preferred manner, forming no part of the present invention.

As the machinery deck **16** is rotated relative to the combination bull gear and roller path **58**, and consequently, relative to the pedestal **12**, the struts **34** and **36** will cause the counterweight **24** to turn with the check. This will cause the wheels **78** to roll around the outer periphery of the cylindrical counterweight support collar **72**. The downward component of the weight of the counterweight will be carried by the machinery deck at the pin **30**. This pin **30** is spaced relatively close to the axis of rotation of the deck, thus creating much less bending moment than would be the case if it were supported at the outermost rear end portion of the deck **16**.

In the no load condition, the maximum vertical "dead weight" effect of the counterweight acts at a lever arm length equal to the horizontal distance between the pin **30** and the vertical axis of rotation of the machinery deck **16**. Since this is the maximum rearward bending stress condition, and since it is present under minimum or no load conditions only, the various elements of the counterbalancing crane are easily designed to safely handle such loading.

This no load condition is also the condition of maximum normal stress of the counterweight **24** acting through the counterweight support means **76** and onto

the pedestal mounted cylindrical counterweight support collar **72.** Because the cylindrical wall of collar **72** is vertical, there is no component of force transmitted in the downward direction through the support collar **72** and onto the pedestal **12.** The only force here involved is that in direction perpendicular to the axis of the support collar and lying in a generally horizontal plane. Thus by providing sufficient rigidity and stiffness in the pedestal and in the pedestal support collar and in the radially outwardly extending plates **74, 74** which support the collar on the pedestal to support a known maximum force, safe and economical design is readily achieved.

In order to figure the necessary strength of the parts to support a maximum load to be handled, after the no-load bending effects set out above have been considered, the compressive loading caused by the weight of the counterbalancing crane and the counterweight, plus the weight of the maximum working load for which the crane is being designed are taken into consideration.

When one of the load hooks **52** is engaged with a working load, and machinery **54** is employed to reel in the load line **50** so that the crane **10** can lift that load, the boom **18** is positioned or maintained in its upright position through the first suspension **44** and by the connection of that first suspension to the tip of the mast **22.** The mast, first suspension, boom, the load hooks **52** and the work load (not shown) are supported in place by the second suspension **42,** connected as it is between the top of the counterweight **24** and tip of mast **22.** As more and more weight is exerted on the load lines **50,** the upward forces existing in second suspension **42** are increased. As this happens, the downward force component on the pin **30** is lessened, and the horizontal force component through the counterweight wheels **78** to the cylindrical counterweight support collar **72** is likewise lessened.

As this loading continues, a point is reached where there is no longer any force being exerted by the counterweight wheels **78** on the outer cylindrical surface of the support collar **72.** At this point, the counterweight tends to pivot about the pin **30** so that the wheels **78** tend to move clear of the collar **72.** This movement is resisted by the shims **90** and outermost rearward end deck bracket **88** at the outermost end of the rearward portion **32** of the machinery deck **16.** But the machinery deck itself is a flexible structure in and of itself and is not rigid. Therefore, once the entire weight of the counterweight is supported on second suspension **42,** additional counterbalancing effect is obtained by the flexing of the rearward portion **32** of machinery deck **16,** as the load on the load lines **50** is increased. Additional load can be handled until the designed limits of the total loading of the flexible deck and of the weight of the counterweight is reached.

As pointed out above, when the load is first picked up, the upward force exerted by the load, the boom, first suspension and the mast on the second suspension **42** and consequently on the counterweight, tend to lighten the loading of the rearward portion of the machinery deck. The forward portion of that deck is, at the same time, being downwardly loaded as the downward component of the weight on the load line is transmitted at the points of pivotal mounting of the mast and boom to the forward portion of the machinery deck. Thus the maximum tendency of the machinery deck to be "bent over backwards" is present in the no-load condition. This loading of the machinery deck toward the rear approaches and reaches a minimum as the load is picked up, and then passes to a maximum tending to load the front end of the machinery deck as the entire weight of the counterweight is picked up by the mast acting through the second suspension **42,** and as the rearward portion of the deck is flexed as the counterweight continues to be pulled upwardly.

As will be seen from the foregoing description, the horizontal force components due to the weight of the counterweight in the unloaded condition are carried by the counterweight load bearing entity **70.** As the entire weight of the counterweight is supported in counterbalancing configuration, and the bearing platform on the counterweight cooperating with the outermost rear end of the deck prevents further upward movement of the counterweight, the horizontal force components disappear.

Under no load conditions, the downward effect of the counterweight on the rotatable machinery deck is minimized because there is no connection between the counterweight and the outermost rear end of the deck until such time as the entire weight of the counterweight has come into counterbalancing configuration. At this point, the counterweight is connected under the outermost rear end portion of the machinery deck, and the whole weight of that portion of the machinery deck and the flexible strength of the rearward portion of the deck is added to the counterbalancing effect of the counterbalance. This is so whether the counterweight load bearing entity is a cylindrical collar mounted in concentric relation to the axis of rotation of the platform on a pedestal, as shown herein, or whether the counterweight load bearing entity is a horizontally disposed ring or track such as disclosed in U.S. Pat. No. 3,485,383.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a crane having a first support, a machinery deck rotatably mounted on a generally vertical axis with respect to said first support, an upstanding mast and an upstanding boom both pivotally mounted on a forward portion of the machinery deck for movement in a vertical plane passing through the axis of rotation of the machinery deck with respect to the support, a first suspension, means mounting said first suspension between an upper portion of said mast and an upper portion of said boom, a load line extending over the point of said boom, means for rotating said deck, means for powering the load line, and a load handling device supported by the load line hanging from the point of the boom; the improvement including:

A. a counterweight;

B. means for pivotally supporting said counterweight at a rearward portion of the machinery deck for free swinging movement downwardly with respect to that deck;

C. counterweight support wheels mounted with respect to the counterweight to rotate on axes lying in planes containing the axis of rotation of the deck;

D. a counterweight load bearing entity fixedly positioned with respect to said first support and providing a counterweight load bearing surface in position to receive said counterweight support wheels;

E. means including said counterweight support means to cause said counterweight to rotate with

said deck in a horizontal plane;

F. a second suspension between said counterweight and an upper portion of said mast; and

G. said counterweight being provided with a bearing platform in position to come into bearing relationship to said rearward portion of said deck when said counterweight is lifted by said second suspension means from load transmitting relationship with said counterweight load bearing entity.

2. The crane structure of claim **1** wherein the support is an upstanding pedestal, wherein the counterweight load bearing entity includes a cylindrical counterweight support collar fixedly mounted with respect to the pedestal to be concentric with the axis of rotation of the machinery deck with respect to the pedestal, and wherein the counterweight support wheels are rotatably mounted on axes parallel to the axis of said deck rotation.

3. The crane of claim **2** wherein said bearing platform is constituted as an integral portion of said counterweight and is situated in vertically underlying relationship with respect to an outermost rearward end portion of the machinery deck.

4. The crane of claim **3** and shims between the bearing platform of the counterweight and said outermost rearward end portion of the machinery deck, said shims lying in intimate bearing, contacting, force transmitting relationship with respect to both said bearing platform and said outermost rearward end portion of said deck to insure that every attempted upward movement of said counterweight with respect to said deck will be transferred immediately and completely to the rearward portion of said deck.

5. The crane of claim **3,** wherein said counterweight is pivoted to said rearward portion of said machinery deck at a point intermediate the outermost rearward end portion of said deck and said vertical axis of deck rotation.

6. The crane of claim **5,** wherein said point of pivotal support of said counterweight with respect to a rearward portion of said deck is situated at a substantial distance from the outermost rearward end portion of said deck.

7. The combination as specified in claim **6** wherein said means for pivotal support of said counterweight at a rearward portion of said deck includes upper and lower struts each pinned, respectively, to upper and lower portions of the counterweight and each extending to and encompassing the axis of said point of pivotal support of said counterweight with respect said rearward portion of said deck.

8. The crane of claim **7** wherein said counterweight support wheels include at least two sets of pairs of wheels, each set being rotatably mounted about spaced apart vertical axes at opposite ends of wheel beams, intermediate portions of such wheel beams being pivotally mounted with respect to spaced apart lower portions of said counterweight.

9. The crane of claim **8** wherein said pedestal is positioned in adjacent surrounded relationship to a body of water, and wherein said counterweight includes a hollow counterweight tank and water drawn from said body of water filling said tank.

10. The crane of claim **9** wherein said pedestal is mounted fixedly with respect to the earth floor underlying said body of water.

11. The crane of claim **9** wherein said pedestal is fixedly mounted with respect to a vessel supported by said body of water.

12. In a crane having an upstanding pedestal, a machinery deck rotatably mounted on a generally vertical axes with respect to said upstanding pedestal, an upstanding mast and an upstanding boom both pivotally mounted on a forward portion of the machinery deck for movement in a vertical plane passing through the axis of rotation of the machinery deck with respect to the pedestal, a first suspension between an upper portion of said mast and an upper portion of said boom, a load line extending over the point of said boom, means for rotating said deck, means for powering the load line, and a load handling device supported by the load line hanging from the point of the boom; the improvement including:

A. a counterweight;

B. means for pivotally supporting said counterweight at a rearward portion of the machinery deck at point intermediate the outermost rearward end portion of said deck and said vertical axis of deck rotation and at a substantial distance from the outermost rearward end portion of said deck, said means supporting said counterweight for free swinging movement downwardly with respect to said deck and said means including upper and lower struts each pinned, respectively, to upper and lower portions of the counterweight and each extending to and encompassing the axis of said point of pivotal support of said counterweight with respect to said rearward portion of said deck;

C. at least one counterweight support wheel mounted with respect to a lower portion of the counterweight to rotate on an axis lying in a vertical plane;

D. a cylindrical counterweight support collar fixedly mounted with respect to the pedestal to be concentric with the axis of rotation of the machinery deck and providing a counterweight load bearing surface in position to receive said counterweight support wheel;

E. means including said counterweight support means to cause the counterweight to rotate with said deck; and

F. a second suspension between said counterweight and an upper portion of said mast.

13. The crane of claim **12** wherein there are at least two wheel beams and at least two sets of pairs of wheels, each set being rotatably mounted about spaced apart vertical axes at opposite ends of said wheel beams, intermediate portions of such wheel beams being pivotally mounted with respect to spaced apart lower portions of said counterweight.

14. The crane of claim **13** wherein said pedestal is positioned in adjacent surrounding relationship to a body of water, and wherein said counterweight includes a hollow counterweight tank and water drawn from said body of water filling said tank.

15. The crane of claim **14** wherein said pedestal is fixedly mounted with respect to the earth floor underlying said body of water.

16. The crane of claim **14** wherein said pedestal is fixedly mounted with respect to a vessel supported by said body of water.

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