United States Patent [19]

Pottorff et al.

[11] **3,726,416**

[45] **Apr. 10, 1973**

[54] **EXTENDABLE COUNTERWEIGHT FOR CRANES AND METHOD OF MANIPULATING**

[75] Inventors: **Donald R. Pottorff**, Mercersburg, Pa.; **William E. Wright**, Hagerstown, Md.

[73] Assignee: **Walter Kidde & Company, Inc.**, Clifton, N.J.

[22] Filed: **Dec. 15, 1970**

[21] Appl. No.: **98,430**

[52] **U.S. Cl.**.....**212/49**, 212/48

[51] **Int. Cl.**.....**B66c 23/72**

[58] **Field of Search**.....212/48, 49

[56] **References Cited**

UNITED STATES PATENTS

3,240,353	3/1966	Leavesley	212/49
733,128	7/1903	Bennett et al.	212/48 X
142,740	9/1873	Serrell	212/48

FOREIGN PATENTS OR APPLICATIONS

1,038,429	9/1953	France	212/48

Primary Examiner—Evon C. Blunk

Attorney—Brady, O'Boyle & Gates

[57] **ABSTRACT**

A counterweight for large mobile cranes or like machines features a power-operated extendable and retractable counterweight carriage and latching means. A suspension cable for the counterweight has a connection with a movable telescoping section of the crane boom so that the crane boom hydraulic system may be employed to raise and lower the counterweight and the need for a separate system is avoided. A safety control mechanism in the path of movement of the counterweight when it is being elevated prevents possible damage to the crane superstructure.

16 Claims, 11 Drawing Figures

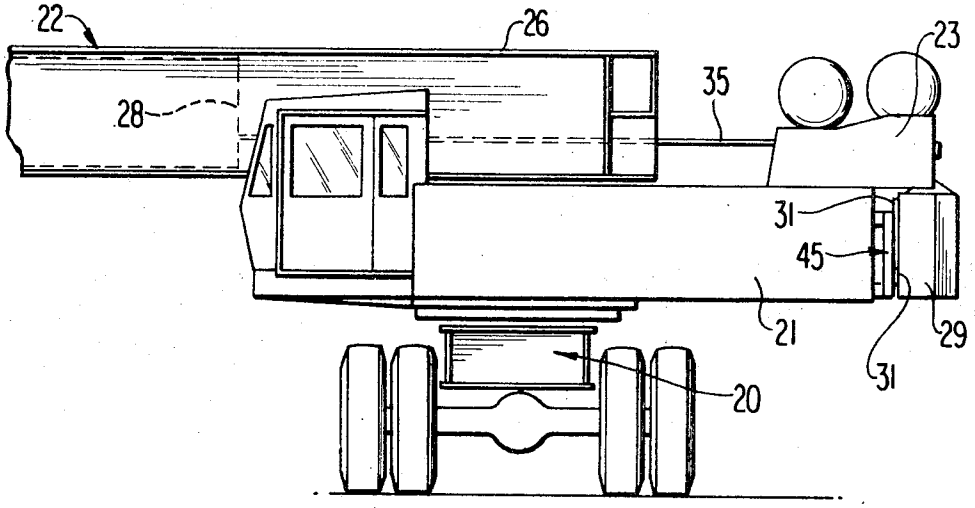


FIG. 1

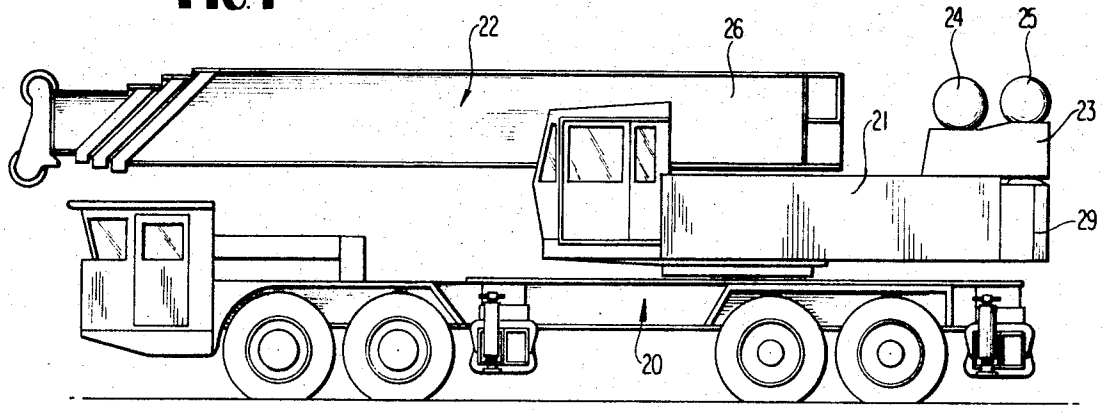


FIG. 8

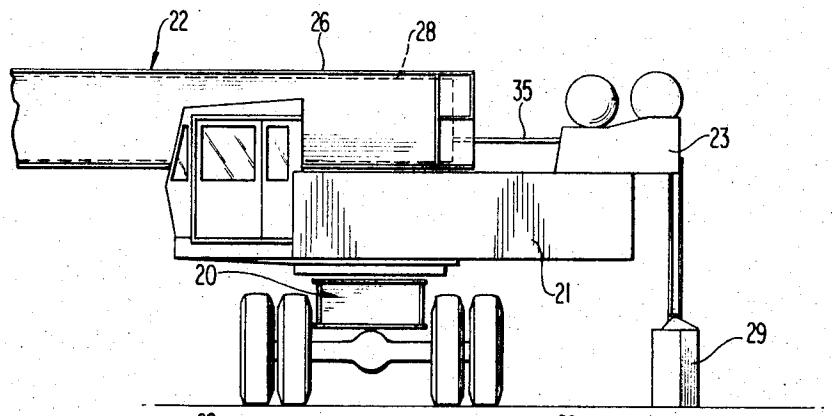
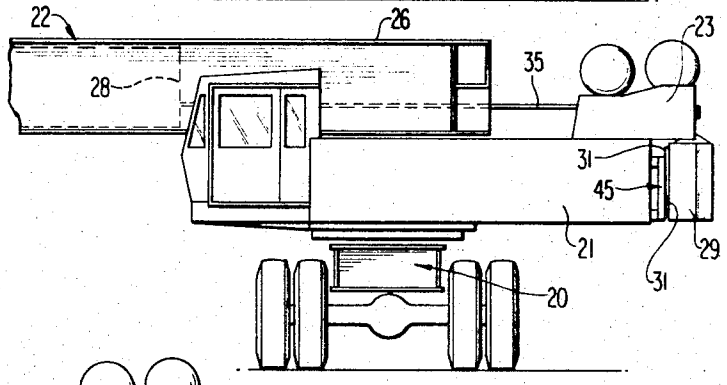


FIG. 9



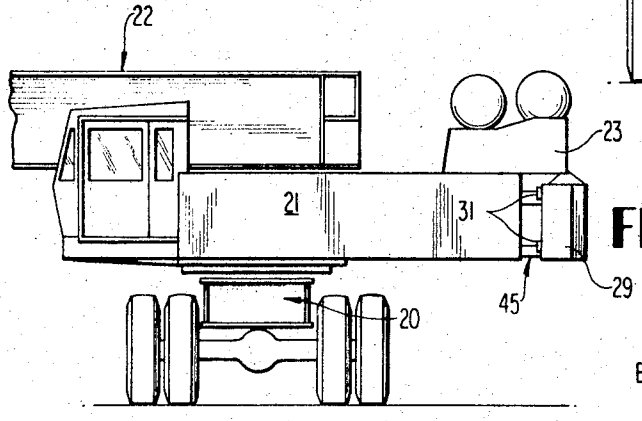


FIG. 10

INVENTORS
DONALD R. POTTORFF
WILLIAM E. WRIGHT

BY Brady, O'Boyle & Gates

ATTORNEYS

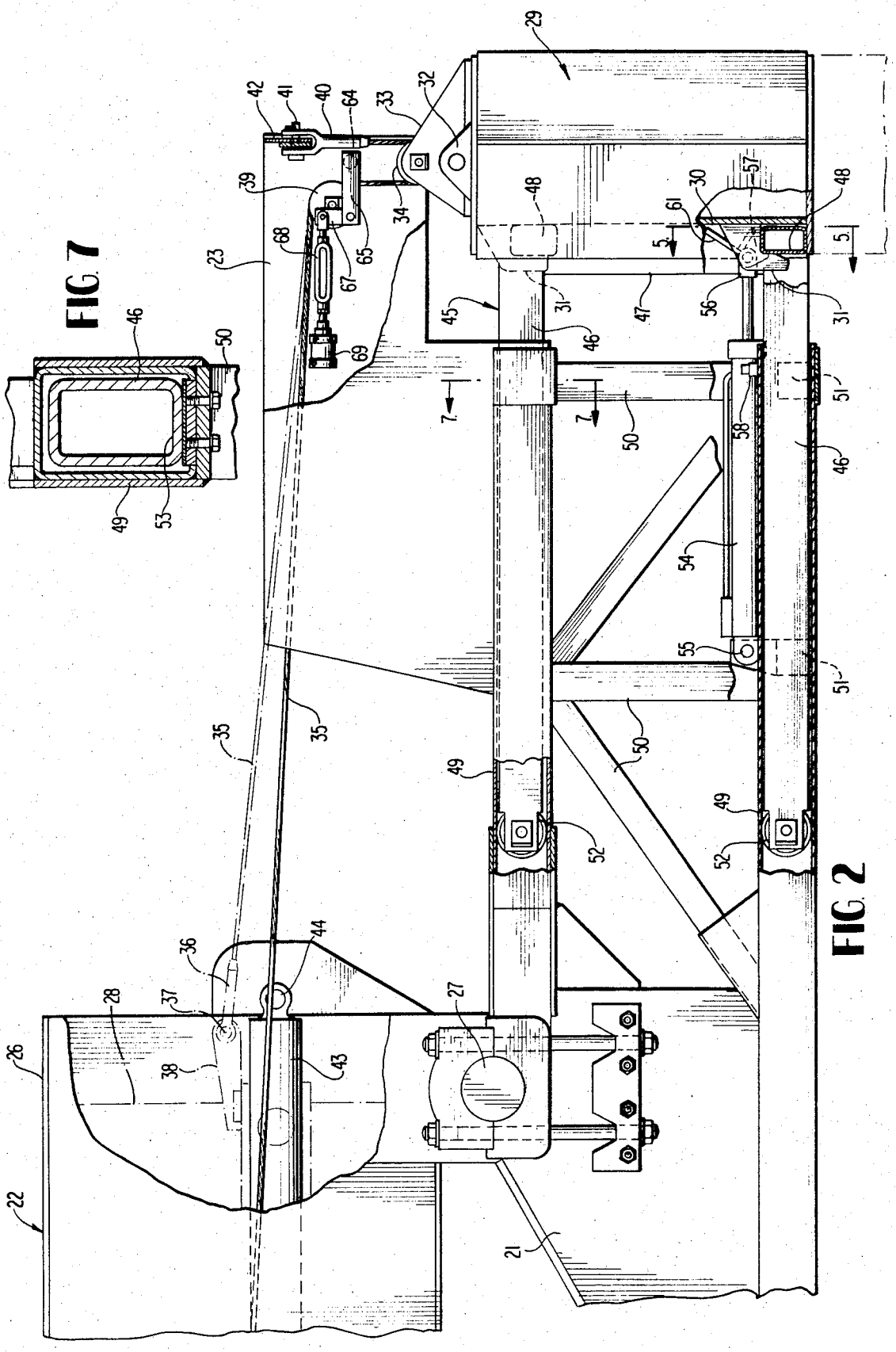

29
42
41
40
64
33
32
39
34
48
30
57
61
5
68
23
65
67
31
47
56
45
46
69
7
50
58
51
46
54
55
35
49
52
44
36
37
28
27
26
38
43
22
21

FIG. 2

FIG. 7

FIG. 3

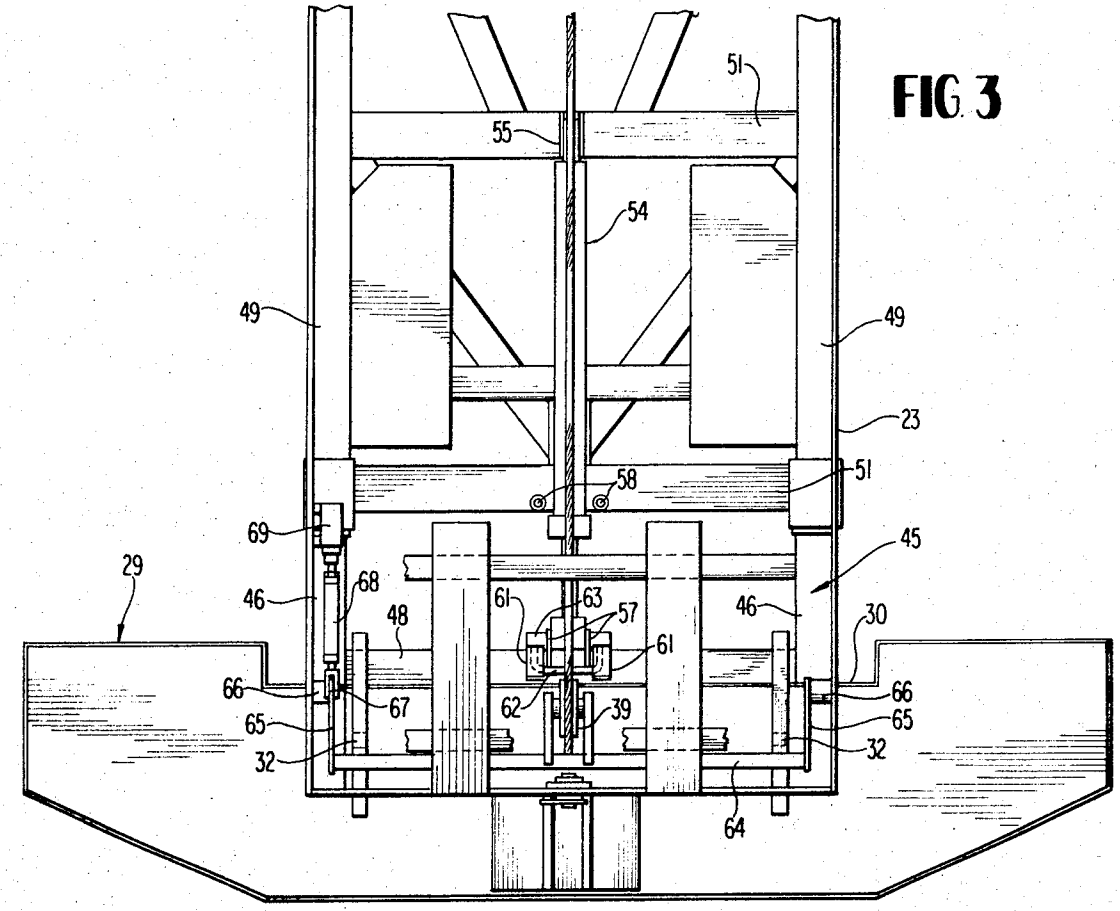

51
55
54
49
49
23
58
51
69
45
29
68
46
61
63
57
46
30
48
61
66
67
62
39
66
65
65
32
32
64

FIG. 4

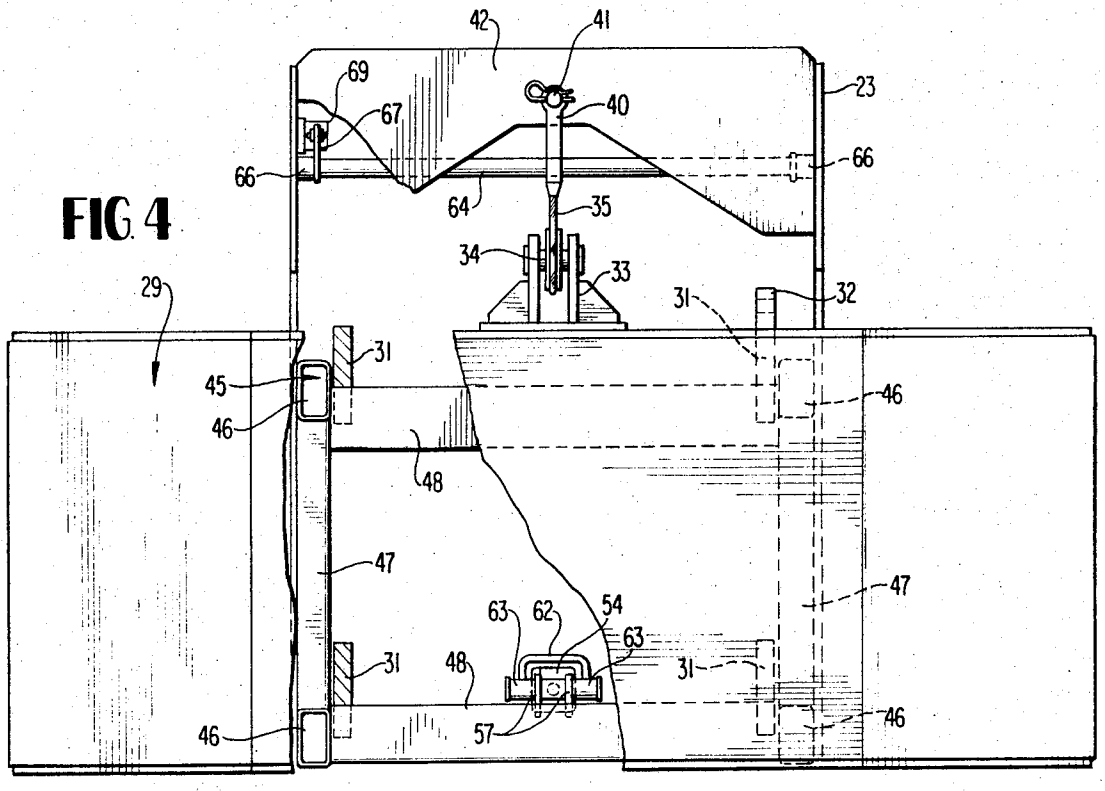

42
41
69
23
67
40
66
66
64
35
34
33
31
32
29
31
45
46
46
48
47
47
63
62
54
63
31
48
31
46
57
46

FIG. 5

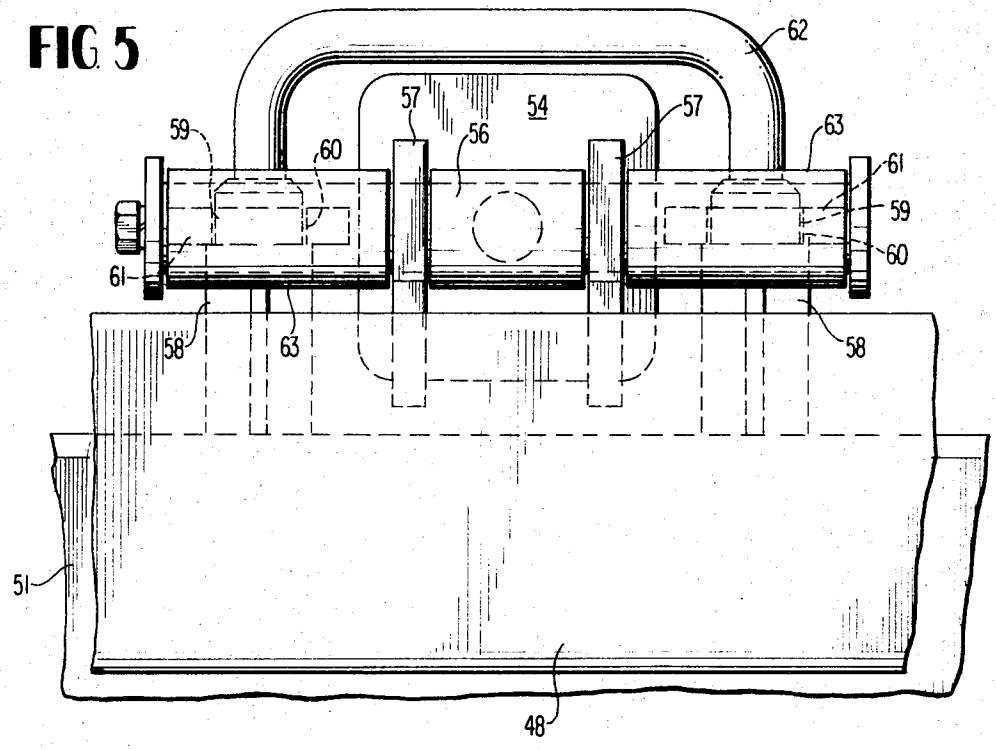
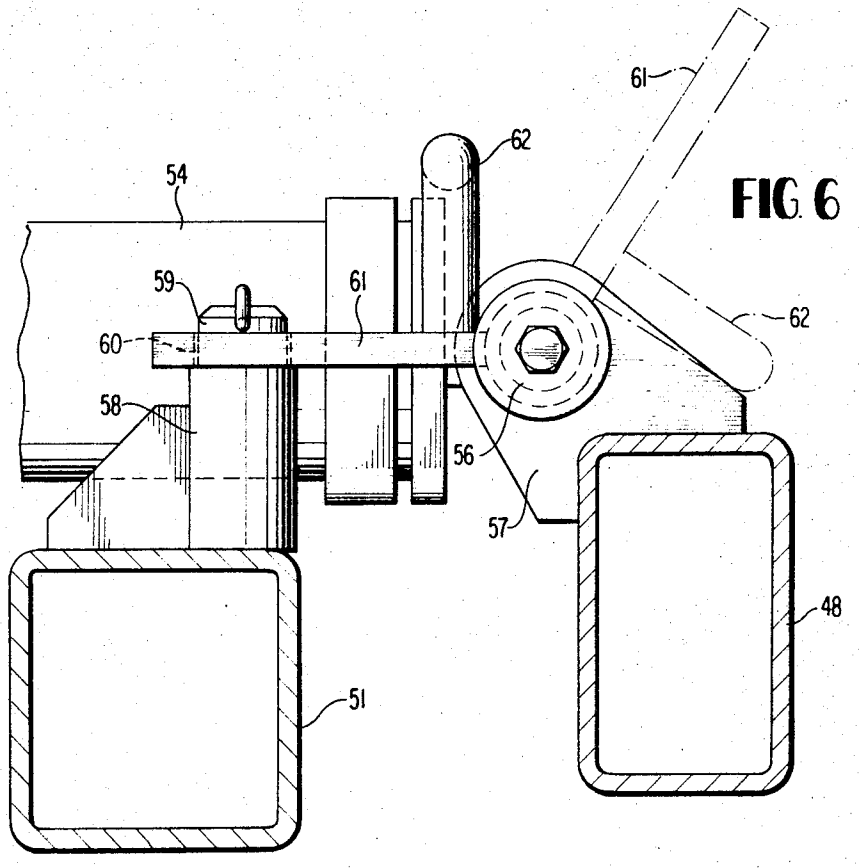

62
57
54
57
59
56
63
60
61
59
60
61
58
63
58
51
48

FIG. 6


61
62
54
59
61
62
60
58
56
57
48
51

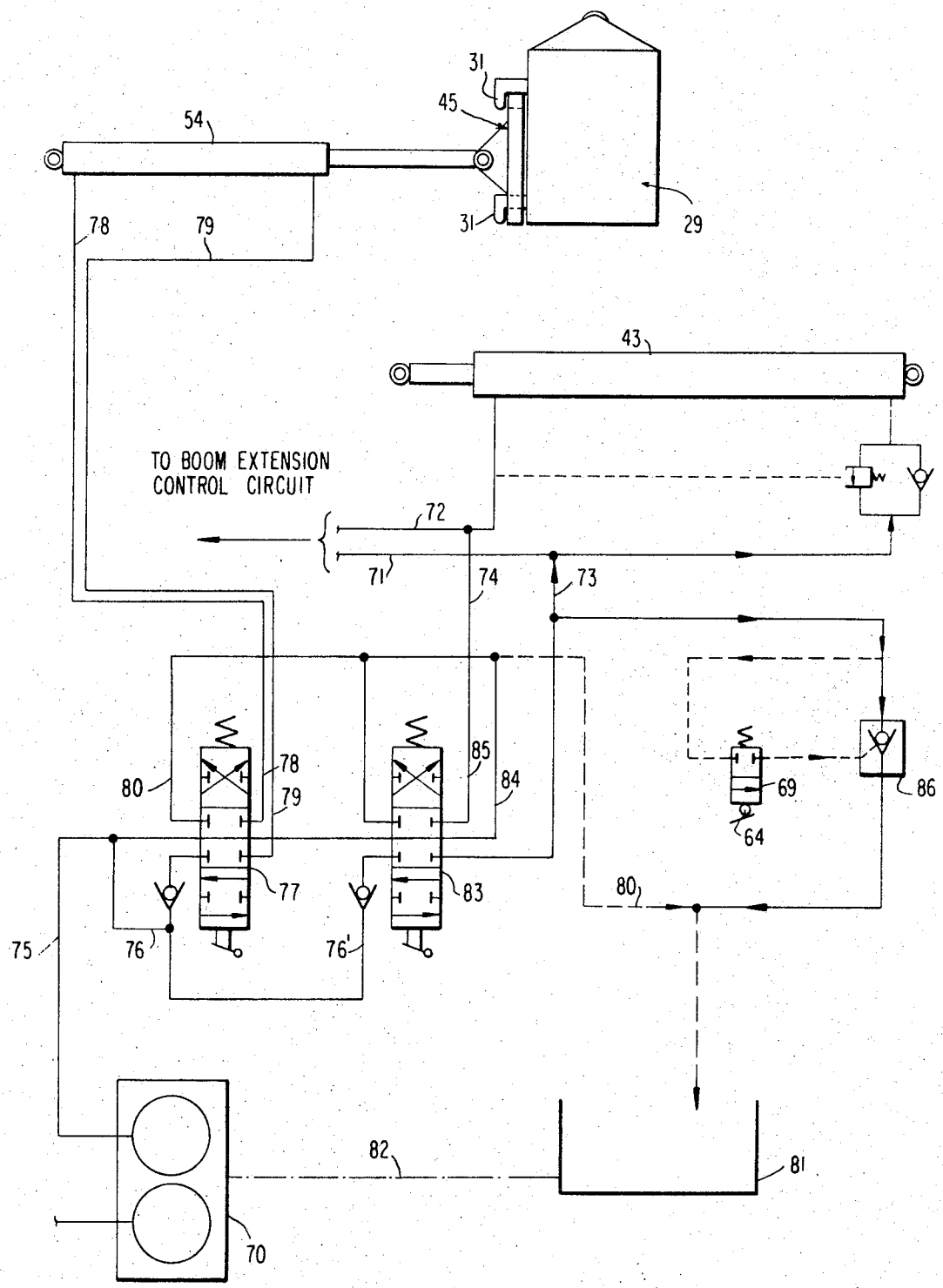

31
45
54
31
29
78
79
43
TO BOOM EXTENSION
CONTROL CIRCUIT
72
71
74
73
80
78
79
85
84
69
86
64
77
83
80
75
76
76'
82
81
70

FIG. 11

EXTENDABLE COUNTERWEIGHT FOR CRANES AND METHOD OF MANIPULATING

BACKGROUND OF THE INVENTION

Shiftable counterweights for cranes and like machines including cranes having hydraulically operated telescopic booms are known in the art. Where such counterweights are employed, it has been common practice to provide a separate and distinct hydraulic operating system for the heavy counterweight and it has not been proposed to use the crane boom hydraulic system to raise and lower the counterweight. This has resulted in an uneconomical overall construction requiring two separate operating systems or mechanisms, as stated.

Additionally, with the ever-increasing capacity or size of hydraulic cranes, the mass of the counterweight has increased correspondingly to a degree where its support and manipulation has become a real problem and the prior art has not offered a solution to this problem. Therefore, the objectives of the invention are to provide a simplifed and practical method of manipulating the large counterweight and an improved sturdy mounting or support means for the counterweight including a very stable extendable and retractable counterweight carriage having low friction engagement with the crane superstructure. The invention also incorporates certain safety features and other features and advantages which will become apparent during the course of the following detailed description.

BRIEF DESCRIPTION OF DRAWING FIGURES

FIG. **1** is a side elevation of a mobile crane having the counterweight support and manipulating means of the invention;

FIG. **2** is an enlarged fragmentary side elevation of the counterweight and adjacent crane structure and manipulating means, with parts omitted and parts in section;

FIG. **3** is a plan view of the counterweight and associated mounting and manipulating elements shown in FIG. **2**;

FIG. **4** is a rear elevation, partly broken away and partly in section, of the elements in FIG. **3**;

FIG. **5** is an enlarged fragmentary vertical section taken on line **5**—**5** of FIG. **2**;

FIG. **6** is a side elevation of the structure shown in FIG. **5**, partly in section;

FIG. **7** is an enlarged fragmentary vertical section taken on line **7**—**7** of FIG. **2**;

FIG. **8** is a fragmentary side elevation of the crane with the crane boom turntable turned **90** degrees from its position in FIG. **1** and with the counterweight lowered to the ground;

FIG. **9** is a similar view showing a step in the method of raising the counterweight and connecting it to a support carriage; and

FIG. **10** is a similar view showing the counterweight installed on the support carriage with the carriage extended to a use position;

FIG. **11** is a hydraulic circuit schematic including controls for the counterweight carriage cylinder and the hydraulic ram which operates the boom inner midsection and also the raising and lowering of the counterweight.

DETAILED DESCRIPTION

Referring to the drawings in detail wherein like numerals designate like parts, and referring first to FIG. **1**, there is shown in this figure a mobile crane including a motorized carrier **20** and a turntable-mounted superstructure **21** on the carrier upon which a multi-section hydraulically operated extensible and retractable telescoping crane boom **22** is pivotally mounted. The superstructure **21** includes an elevated rear end portion **23** for the mounting of winches **24** and **25**.

Referring next to FIGS. **2** through **4**, it may be seen that the telescopic crane boom **22** embodies a base section **26** which has a main pivotal connection with the turntable-mounted superstructure **21**, indicated at **27**. The crane boom further comprises an inner mid-section **28** shown fully retracted in phantom lines in FIG. **2**. The inner mid-section **28** is also shown retracted in FIG. **8**. It is shown extended from the base section **26** in FIG. **9** as where the counterweight is being elevated.

Continuing to refer to FIGS. **2**, **3** and **4**, the large counterweight is indicated by the numeral **29** and this counterweight is preferably fabricated from heavy plate stock and filled with metal scrap or like heavy ballast. If desired, the counterweight may be a solid steel casting. As shown in FIGS. **3** and **4**, the counterweight **25** is elongated transversely and spans substantially the rear end of the superstructure **21**. The counterweight has a wide shallow notch **30** in its interior side to receive structural elements of its mounting carriage, to be described. The counterweight additionally embodies upper and lower pairs of laterally spaced and vertically aligned rigid mounting hooks **31** preferably welded to the counterweight. The top of the counterweight is equipped with apertured lifting lugs **32** which may be integral extensions of the upper mounting hooks **31**, see FIG. **4**. The lugs **32** are utilized, for example, to lift the counterweight for placing it onto a special truck or onto the deck of the crane carrier **20** when it is completely separated from its mounting.

At its transverse center, a sturdy mounting bracket **33** for a single counterweight suspension sheave **34** is rigidly secured to the top of the counterweight. The sheave **34** is spaced somewhat above the top of the counterweight and is located accurately midway between its ends and forward and rear sides so that the counterweight, when suspended from the sheave **34**, will be balanced.

A counterweight cable **35** has a clevis **36** on one end thereof detachably connected at **37** to a coupling element **38** on the extensible and retractable boom inner mid-section **28**. The cable **35** extends rearwardly generally horizontally and is trained over a sheave **39** on the raised superstructure extension **23** above and slightly forwardly of the sheave **34**. The cable **35** then extends downwardly and under the sheave **34** and then upwardly and has another clevis **40** on its rear end detachably coupled at **41** to a rear vertical plate **42** of the superstructure. It should be explained in connection with FIG. **2** that the cable **35** shown in full lines is positioned to maintain the counterweight elevated and mounted on its carriage. At this time, the boom inner mid-section **28** is extended forwardly approximately as shown in FIG. **9**. The cable **35** is also shown in phantom lines in FIG. **2** as it would be positioned when the boom

section 28 is retracted and the counterweight is lowered to the ground. This condition is also shown in FIG. 8. The phantom line illustration in FIG. 2 facilitates showing the clevis 36 and coupling elements 37 and 38 more clearly in the drawings. Also shown in FIG. 2 is the extension and retraction hydraulic ram 43 for the boom inner mid-section 28 having one end coupled at 44 to the boom base section and its other end suitably coupled to the inner mid-section 28 in a conventional manner. It may be seen that the existing ram 43 forming a part of the crane boom hydraulic system is utilized through the cable means 35 to raise and lower the counterweight 29, and thus the necessity for a separate and distinct hydraulic system or mechanism for raising and lowering the counterweight is avoided, resulting in a considerable economy.

The above-described arrangement for raising and lowering the counterweight is used in conjunction with a horizontally extendable and retractable counterweight carriage 45 whose construction and operation will now be described. The carriage 45 comprises upper and lower laterally spaced and vertically aligned pairs of horizontal arms 46 which are box-like in cross section, FIG. 7, and which are rigidly interconnected vertically at their rear ends by vertical bars 47. The carriage arms 46 are also rigidly connected transversely at their rear ends by upper and lower transverse horizontal bars 48. It should now be apparent that the counterweight carriage is very rigid and extremely sturdy in all directions.

The carriage arms 46 are received telescopically within a corresponding number of rectangular tubular guide bars or rails 49 supported rigidly on the turntable-mounted super-structure 21 and extending rearwardly of the boom 22 and disposed below the superstructure winch mounting portion 23. The guide rails 49 are rigidly interconnected vertically by suitable bracing 50 and they are also connected horizontally by rigid crossbars 51 shown in FIGS. 2 and 3.

The forward ends of the carriage arms 46 carry guide rollers 52 which operate smoothly inside of the box-like rails 49. The rear ends of the four rails 49 are provided on their lower walls, FIG. 7, with adjustable wear pads 53 frictionally engaging the bottoms of the arms 46. The counterweight carriage 45 is extended and retracted by a single hydraulic ram 54 disposed longitudinally at the transverse center of the superstructure 21 and preferably having its cylinder end coupled at 55 to the rearward crossbar 51 and its rod end coupled at 56 to bracket elements 57 rigid with the lower crossbar 48 of the counterweight carriage. The operation of this ram 54 will be described in connection with the hydraulic circuit schematic in FIG. 11.

As shown particularly in FIGS. 5 and 6, a means is provided to latch the counterweight carriage 45 in the fully retracted or forward position. This means comprises a pair of laterally spaced upstanding latch posts 58 on the rearward crossbar 51 having reduced diameter top end portions 59 adapted to enter locking openings 60 in latch plates 61. These latch plates are rigidly interconnected through a handle 62 and sleeves 63 welded to the ends of the handle. The handle is disposed substantially at right angles to the latch plates 61, as shown. When the carriage 45 is retracted, the handle 62 is grasped to swing the two latch plates 61 upon the axis of the coupling 56 into locking engagement with the posts 58, as shown clearly in FIG. 6. To release the carriage for extension, the handle 62 and plates 61 are swung to the inactive position shown in FIG. 6 in phantom lines. The latch plates and handle will remain in either position by gravity. The two sleeves 63 are rotatably mounted on end extensions of the coupling pin 56 for the rod end of the ram 54 as shown in FIG. 5. These pin extensions are disposed outwardly of the bracket elements 57.

An additional safety feature is provided to prevent elevation of the counterweight 29 beyond a safe distance where it could strike and damage the winch supporting portion 23 of superstructure 21. This elevation limiting means consists of a transverse horizontal sensing bar 64 directly above and in the path of travel of the vertically moving sheave 34, FIG. 2, the ends of the sensing bar 64 being supported on crank arms 65 rotatable in fixed bearings 66 on the adjacent side walls of superstructure portion 23. One crank arm 65 carries an upstanding right angular rigid extension 67, pivotally connected to the rear end of an adjusting turnbuckle 68 whose rear end is connected to a control valve 69 fixedly mounted on the adjacent side wall of superstructure portion 23. The operation of this control valve 69 will be described in connection with FIG. 11 and the overall operation of the system. It will be apparent that whenever the top of the sheave 34 engages and elevates the sensing bar 64, the linkage including elements 65, 67 and 68, FIG. 2, will actuate the control valve 69 to immediately limit the elevation of the counterweight 29 in a manner to be described. This prevents the counterweight from ever striking or injuring the crane super-structure.

It should also be mentioned prior to proceeding with the overall description of operation that the counterweight hooks 31 are adapted to be raised to an elevation above the carriage crossbars 48 while the carriage is retracted clear of the counterweight, and following this, the carriage is extended sufficiently for the counterweight to be lowered and the hooks 31 engaged over the bars 48 to support the counterweight on the carriage, as shown in FIG. 2.

Referring primarily to FIG. 11, one of the main features of the invention resides in the utilization of the movement of the boom inner mid-section 28 under control of the boom hydraulic ram 43 to raise and lower the counterweight 29. Customarily in the art, a separate mechanism or system is required to manipulate the counterweight and this necessity is completely avoided by the invention. FIG. 11 additionally discloses a refinement in the hydraulic system whereby the boom inner mid-section ram 43 is supplied by a pump 70 of lesser capacity (fewer gallons per minute of fluid) than the usual pump supplying the ram 43 with full power to extend and retract the crane boom 22. Stated differently, by virtue of the arrangement in FIG. 11, the ram 43 is operated at reduced power to raising and lowering the counterweight 29, as compared to full or normal power for extending the crane boom. As shown in FIG. 11, the ram 43 is connected by supply and return fluid lines 71 and 72 to the regular boom extension and retraction control circuit and is connected in parallel with the lower capacity pump 70 and control means of FIG. 11 by supply and return fluid lines 73 and 74.

Continuing to refer to FIG. 11, the pump 70 delivers a desired volume of fluid under an adequate pressure through a line 75 and branch line 76 to a first three-way valve 77 which controls the delivery of fluid to and from the counterweight carriage operating ram or cylinder 54. Depending upon the setting of the valve 77 under control of an operator, fluid is delivered from the valve 77 to one end of the cylinder 54 through a line 78 and returned to the valve from the other end of the cylinder through a line 79, or vice versa depending upon whether it is desired to extend or retract the counterweight carriage 45. In either case, a return line 80 from the three-way valve 77 delivers fluid back to a reservoir 81 connected to the pump 70 by a supply fluid line 82.

Another three-way valve 83 controls the flow of fluid to and from the boom inner mid-section ram 43. This valve 83 is supplied with fluid through lines 75, 76 and 76' and, again depending on the adjustment of the valve 83, fluid is delivered to or returned from the ram 43 to extend or retract the same through lines 84 and 85 connecting with lines 73 and 74, as shown. The ram 43 supplied in this manner from the pump 70 will operate at reduced power to raise and lower the counterweight 29 through the medium of the cable 35 and associated elements shown in FIG. 2, as compared to full power through the lines 71 and 72 during normal crane boom extension or retraction operations.

In FIG. 11, the normal flow path of fluid from the valve 83 to extend the ram 43 for raising the counterweight 29 is shown by the arrowheads in the lines 84 and 73. Should the counterweight 29 be elevated to such an extent that the sheave 34 strikes and raises the sensing bar 64 and associated linkage shown in FIG. 2, the control valve 69 will be operated to divert the fluid from the lines 84 and 73 in the opposite direction and back to the return line 80 through a normally closed check valve 86. When the control valve 69 is shifted or opened by movement of the sensing bar 64, a fluid path of decreased resistance is established through this valve as shown by the arrows and this fluid flow is sufficient to open the check valve 86 and allow the fluid to enter the return line 80. Therefore, fluid from the line 84 which would normally extend the ram 43 is diverted back to the reservoir 81 and the elevating of the counterweight 29 is automatically arrested before the counterweight can strike and damage the structure 23.

The general mode of operation of the mechanism or the method of handling the counterweight may be summarized as follows.

Assuming the counterweight 29 to be mounted on the carriage 45 as shown in FIGS. 2 and 10, the desired positioning of the carriage 45 is obtained by operation of the three-way valve 77, as described in connection with FIG. 11. This valve delivers fluid to either side of the piston in the double-acting cylinder or ram 54 to extend or retract the counterweight carriage.

To remove the counterweight 29 from the carriage 45, the cable 35 is connected to the boom inner mid-section 28 and reaved around the sheaves 39 and 34, as described, and connected at its other end to the plate 42, FIG. 2. By operation of the valve 83, the ram 43 is extended sufficiently to raise the counterweight so that the hooks 31 are above the carriage bars 48. The carriage 45 is then retracted into the rails 49 by use of the valve 77, allowing the counterweight to be lowered to the ground as in FIG. 8 by retracting the boom mid-section ram 43 again utilizing the control valve 83. This of course lengthens the vertical loop in the cable 35, as shown in FIG. 8. Mounting of the counterweight onto the carriage 45 is accomplished by a reverse procedure, care being taken to turn the boom and super-structure 21 ninety degrees from the road travel position of FIG. 1 so that the vertically moving counterweight will be clear of the underlying crane carrier 20.

It should be mentioned that FIG. 9 shows the condition where the counterweight and its hooks 31 are raised above the carriage bars 48 as when detaching the counterweight from the carriage or preparing to attach it thereto. In either case, as described, the hooks 31 are raised slightly above the bars 48 and the carriage 45 is either retracted, as when dismounting the counterweight, or extended under the hooks when attaching the counterweight to the carriage. The counterweight is then lowered either to the ground or into engagement with the bars 48 as the case may be. FIG. 10 shows the counterweight hooks 31 coupled to the bars 48 exactly as shown in FIG. 2.

With the counterweight stowed for travel as in FIG. 1 and the carriage 45 fully retracted, the latch mechanism shown in FIGS. 5 and 6 is utilized to latch the carriage 45 securely to the superstructure 21 through posts 58, as described.

In some cases, the counterweight is too heavy to be stowed at the rear of the carrier as shown in FIG. 1. In these cases, the counterweight while resting on the ground and with the cable 35 disconnected from it may be picked up by the crane boom and placed on the deck of the carrier 20 ahead of the turntable or at some other appropriate location. The counterweight may also be lifted onto a special truck. The lifting elements 32 are employed for this purpose.

It will be understood that the cable 35 is installed as shown in FIG. 2 only during the raising and lowering of the counterweight and is normally disconnected and removed when the counterweight has been mounted upon the carriage 45.

The terms and expressions which have been employed herein are used as terms of description and not of limitation., and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof but it is recognized that various modifications are possible within the scope of the invention claimed.

We claim:

1. A method of manipulating a crane counterweight onto or off of a crane, said crane having a hydraulically operated telescoping boom having a load lifting implement on the front end thereof adapted to lift a load including a hydraulic ram for extending and retracting a section of the boom, the method comprising the steps of coupling the counterweight at the rear of the boom to a fixed structural member on the crane and to the end of said movable boom section adjacent the counterweight through a flexible counterweight suspension element, and operating said ram to extend or retract said boom section and thereby reduce or increase slack in said flexible suspension element to raise the counterweight in the vertical plane onto the crane or lower the counterweight in the vertical plane off of the crane.

2. The method as defined by claim 1, and the additional step of engaging the flexible suspension element with guide means on the counterweight and crane to produce a variable length slack suspension loop in the flexible element which is lengthened or shortened in response to retraction or extension of said movable boom section.

3. The method as defined by claim 1, and the additional step of operating said hydraulic ram at reduced power for raising and lowering the counterweight in comparison to its full power operation for extending and retracting the telescoping boom.

4. The method of manipulating a crane counterweight as defined by claim 1 including the additional steps of raising the counterweight to an elevation above the coupling elevation of the counterweight with a crane mounted support carriage, shifting the support carriage toward a coupling position with respect to the counterweight, and then lowering the counterweight into coupling engagement with the carriage and subsequently moving the carriage to shift the counterweight substantially horizontally to a desired use position.

5. The method as defined by claim 1, and the additional step of coupling the elevated counterweight to a movable part of the crane so that the movable part then bodily supports the counterweight.

6. In a crane, a crane boom having an extensible and retractable boom section, a counterweight support structure on the crane, a counterweight, said counterweight support structure including a horizontally extensible and retractable counterweight support carriage, a fluid pressure operated ram connected with said support carriage to extend it toward and retract it from said counterweight, said counterweight adapted to be coupled to and removed from the support structure, means on the crane boom connected to extend and retract said boom section, and a suspension means detachably connectable between said counterweight and the rear portion of said extensible and retractable boom section so that movement of the boom section in one direction can elevate the counterweight in the vertical plane onto the crane and enable it to be coupled to the support carriage on operation of said fluid pressure operated ram to extend said support carriage toward said counterweight, and movement of the boom section in the opposite direction can lower the counterweight in the vertical plane off of the crane after operation of said fluid pressure operated ram to retract said support carriage from said counterweight.

7. The structure of claim 6, and said suspension means including a flexible suspension element having a connection with the counterweight and a connection with the rear portion of said extensible and retractable boom section.

8. The structure of claim 7, and said flexible suspension element comprising a single length of cable having one end detachably connected to the extensible and retractable boom section and its opposite end detachably connected to a fixed structural member on the crane.

9. The structure of claim 8, and first and second cable guide elements on the crane and counterweight and said cable engaging both guide elements between its connected ends to form a variable length counterweight suspension loop.

10. In a crane, a crane boom having an extensible and retractable boom section, a shiftable counterweight support carriage on the crane comprising upper and lower pairs of carriage arms, guide members on the crane receiving said carriage arms telescopically, upper and lower carriage crossbars interconnecting the pairs of arms near their outer ends, a counterweight having upper and lower coupling elements thereon adapted to be engaged with said crossbars in counterweight supporting relationship and disengaged with said crossbars, power means connected with said support carriage to shift the same substantially horizontally with relation to the counterweight, and a suspension means connectable between said counterweight and the extensible and retractable boom section so that movement of the boom section in one direction can elevate the counterweight in the vertical plane onto the crane and enable it to be coupled to the crossbars and movement of the boom section in the opposite direction can lower the counterweight in the vertical plane off of the crane.

11. The structure of claim 10, and interengaging latch means on the crane and support carriage operable to latch the support carriage in a retracted position relative to the crane.

12. The structure of claim 10, and said coupling elements on the counterweight comprising upper and lower laterally spaced pairs of downwardly facing hooks engageable over the tops of the carriage crossbars.

13. The structure of claim 10, and wear pads on the bottoms of the guide members near their outer ends frictionally engaging the bottoms of the carriage arms, and guide rollers on the leading ends of the carriage arms operable within the guide members.

14. The structure of claim 6, and said means on the boom having a connection with the extensible and retractable boom section being another fluid pressure operated ram, a movable sensing element on the crane above the counterweight adapted to be engaged by the counterweight as the latter is elevated by the suspension means, a motive fluid control circuit for operating said another ram, and control valve means connected in said motive fluid control circuit and connected for operation by movement of the sensing element to interrupt extension of said boom section by interrupting the flow of motive fluid in said control circuit to said another ram.

15. In a crane, a crane boom having an extensible and retractable boom section, a counterweight support structure on the crane, said counterweight support structure including a horizontally extensible and retractable counterweight carriage on the crane, a fluid pressure operated ram connected with said carriage to operate it, another ram on the crane boom connected with the extensible and retractable boom section, a counterweight adapter to be coupled to and removed from the support structure, a suspension means connectable between said counterweight and the extensible and retractable boom section so that movement of the boom section in one direction can elevate the counterweight in the vertical plane onto the crane and enable it to be coupled to the support structure and movement of the boom section in the opposite direction can lower the counterweight in the vertical plane off of the crane, a pump for supplying motive fluid to both of said

rams at a volumetric rate and pressure which operates the boom ram at less than full power, and manually operable control valve means interconnected between the pump and said rams and allowing selective extension and retraction thereof.

16. The structure of claim 15, and said control valve means including a pair of three-way valves connected respectively with the carriage operating ram and the boom ram.

* * * * *