United States Patent

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Richmond, Va.
Continuation-in-part of application Ser. No. 757,075, Sept. 3, 1968, now Patent No. 3,533,515.

[54] BOOM STRUCTURE FOR UTILITY TRUCKS AND THE LIKE

16 Claims, 9 Drawing Figs.

[52] U.S. Cl. 212/59, 212/35, 182/2, 212/54
[51] Int. Cl. B66c 23/06
[50] Field of Search 212/66–69, 59, 35, 54; 182/2

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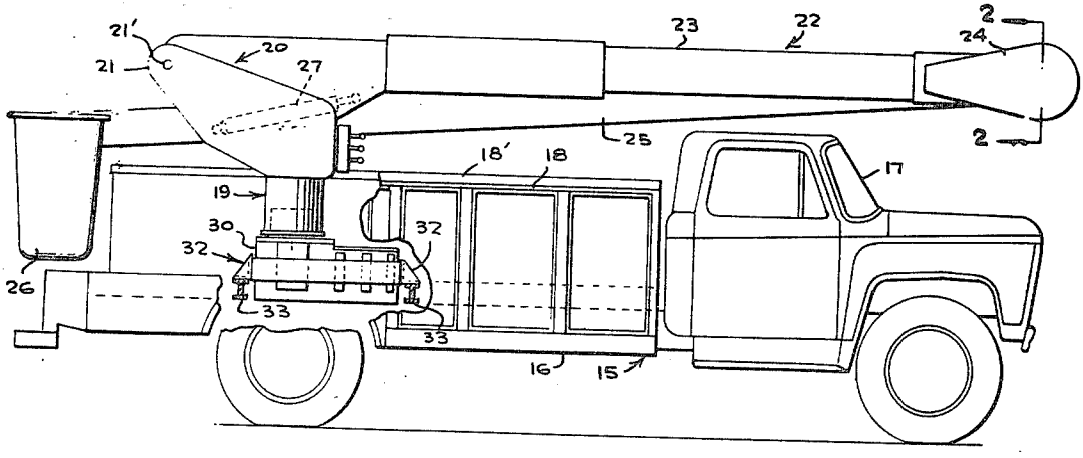
ABSTRACT: An articulated boom structure including a lower boom section and an upper boom section pivoted together at a pivot shaft extending along a horizontal axis through both sections. The shaft is keyed to one of the sections and rotatable in the other, and a pair of crank members coupled to the shaft and hydraulic cylinder units coupled to the crank members and to the other boom section drive the sections to different relative angular positions about the shaft axis.



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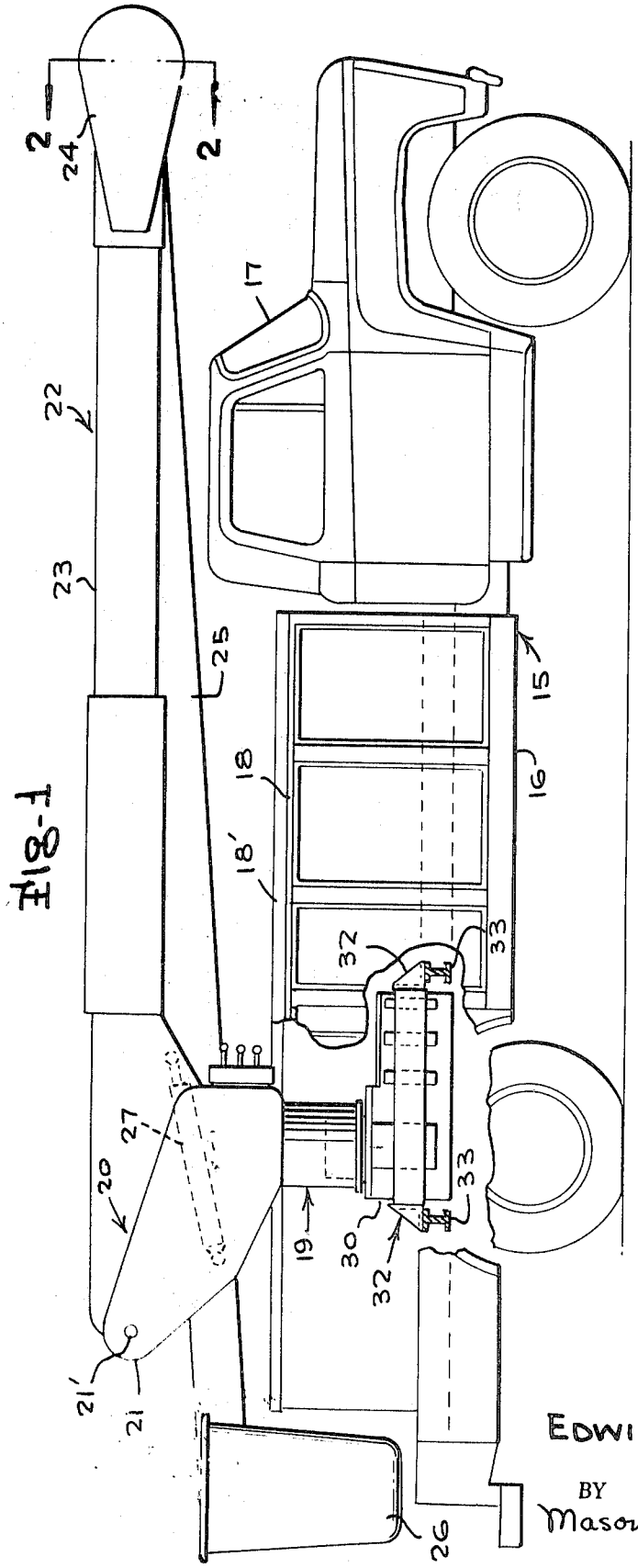

FIG-1

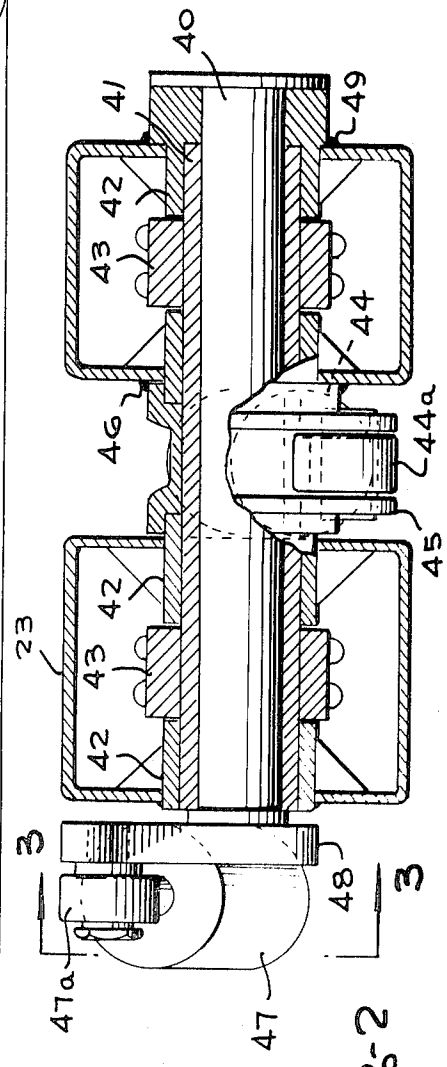

FIG-2

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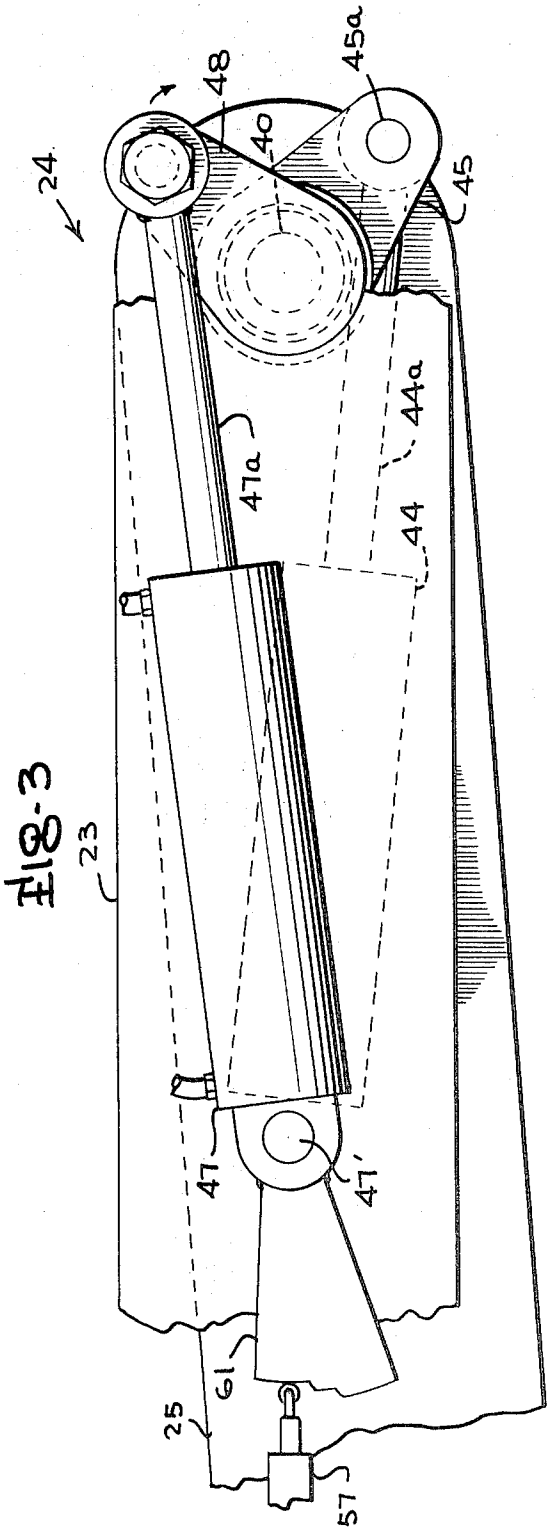

FIG-3

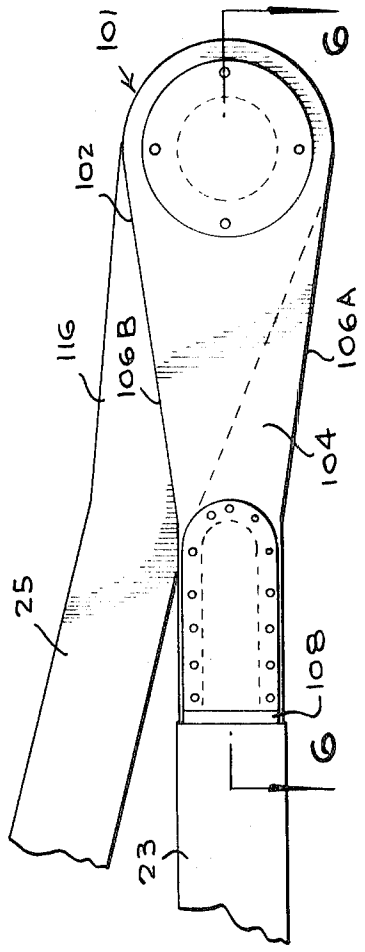

FIG-5

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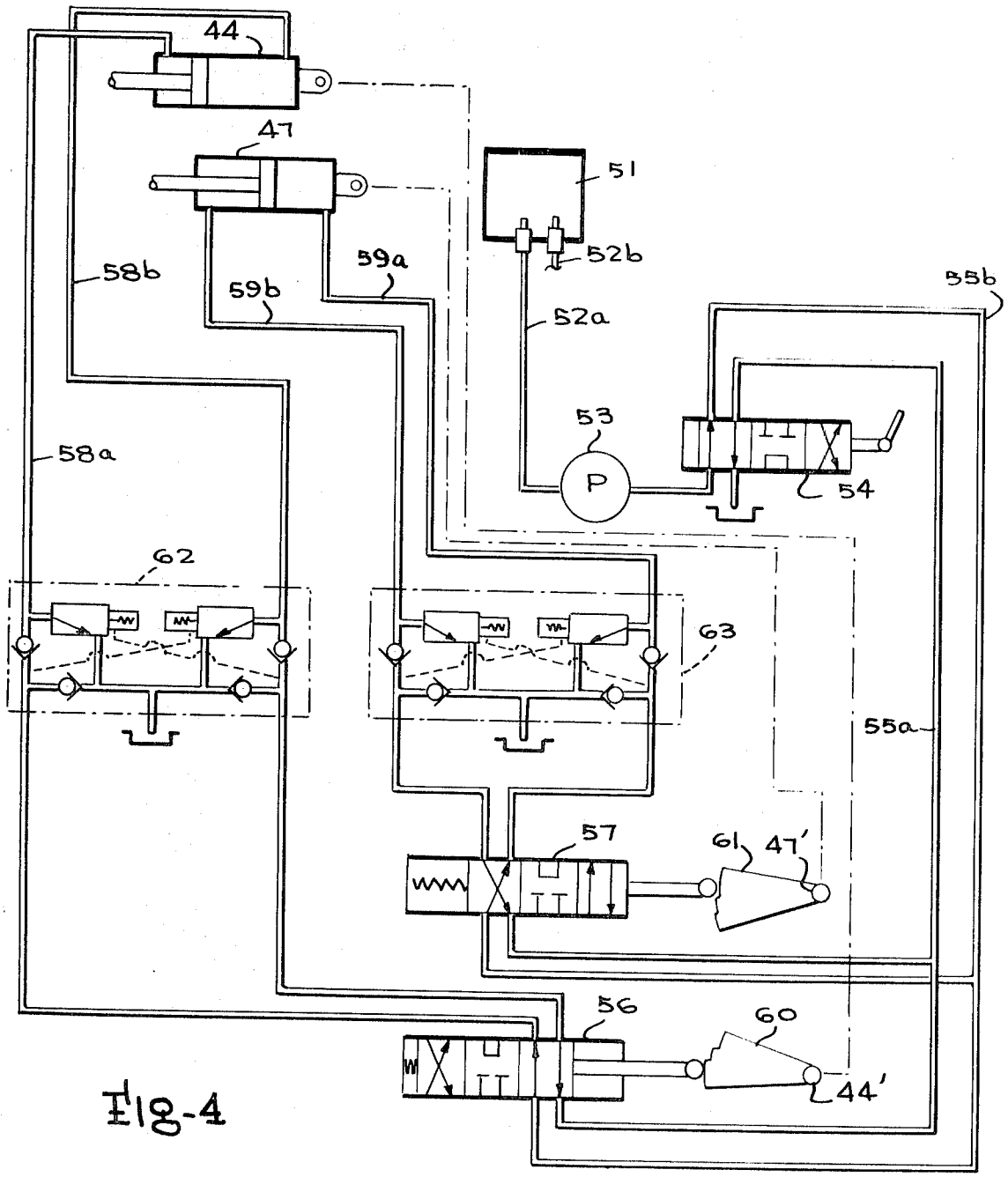

Fig-4

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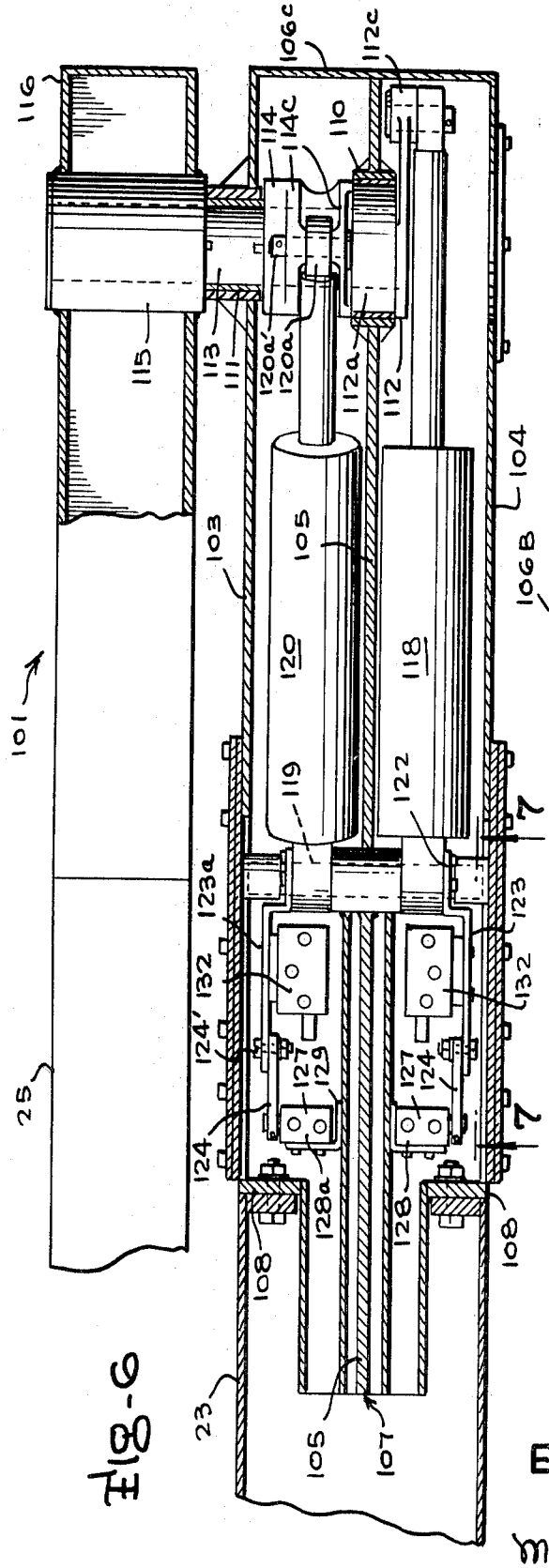

FIG-6

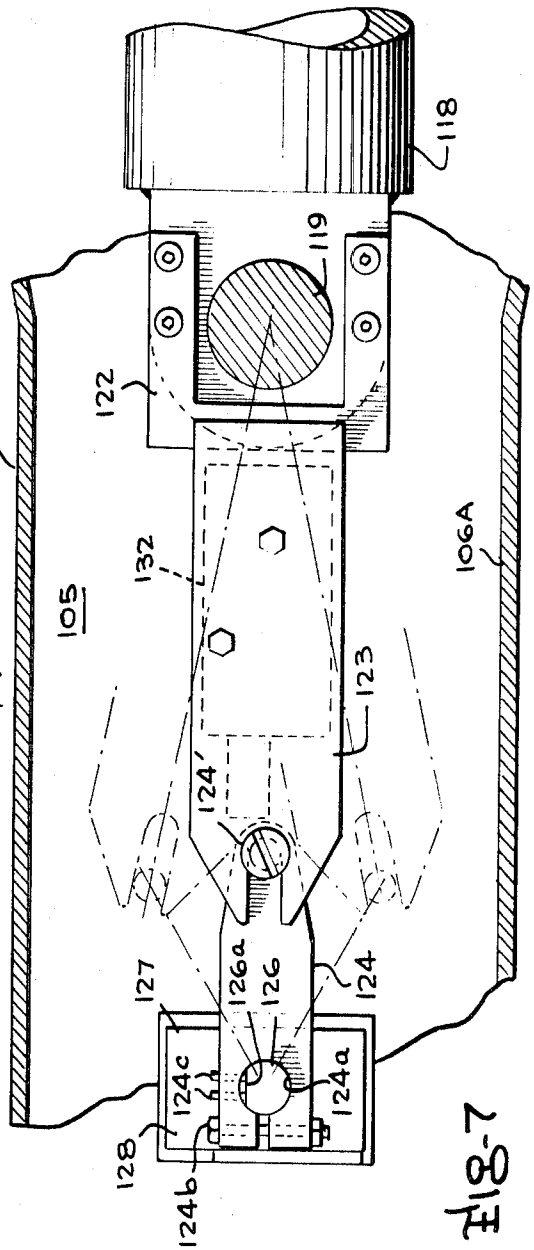

FIG-7

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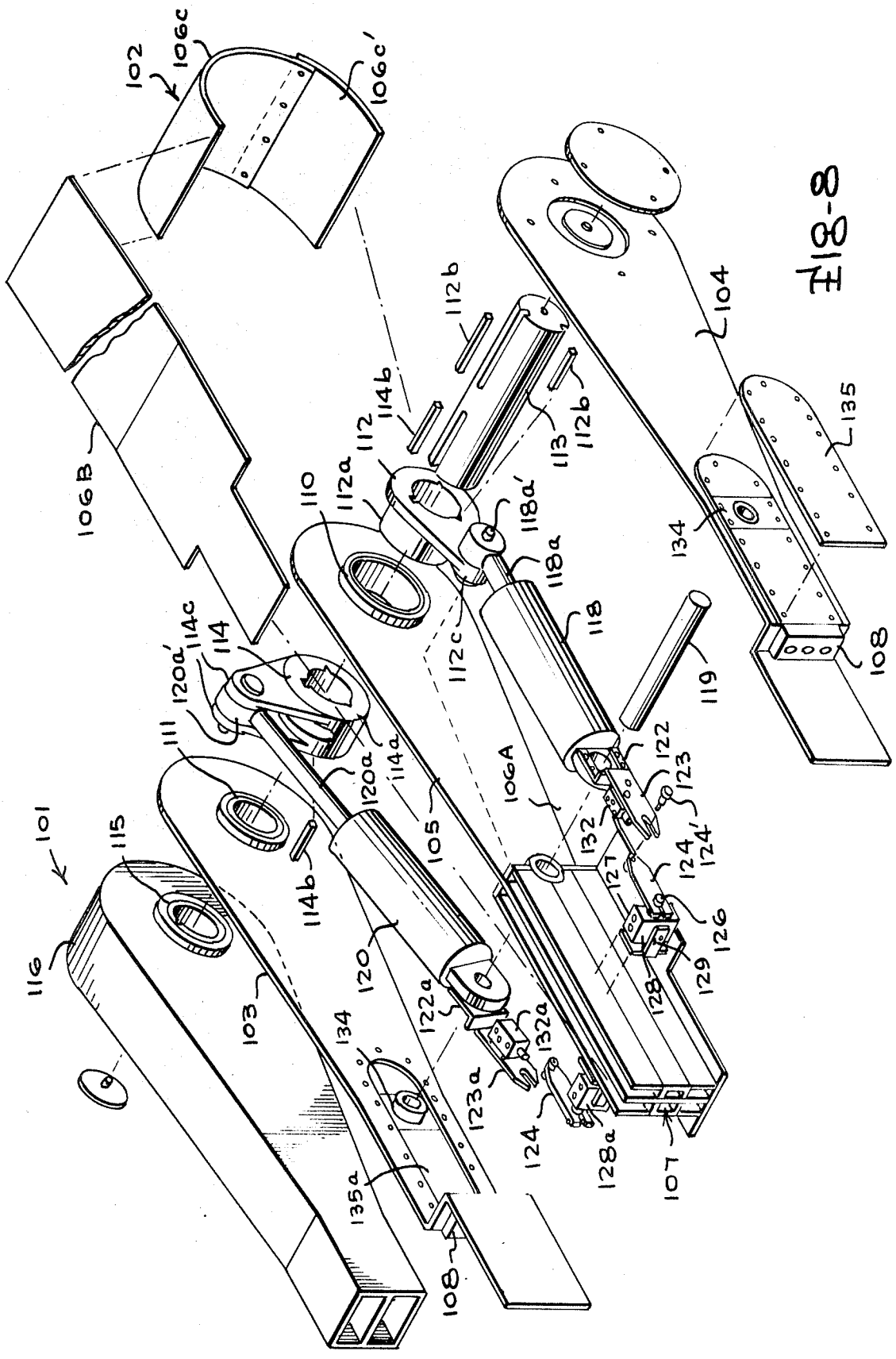
102
106c
106c'
106B
112b
114b
112
112a
110
113
112b'
118a'
118a
118
112c
104
134
135
108
119
120a'
114c
114
111
120a
114a
105
106A
122
123
132
124
124'
127
126
129
128
107
128a
124
123a
132a
122a
120
114b
103
134
135a
108
116
115
101

FIG-8

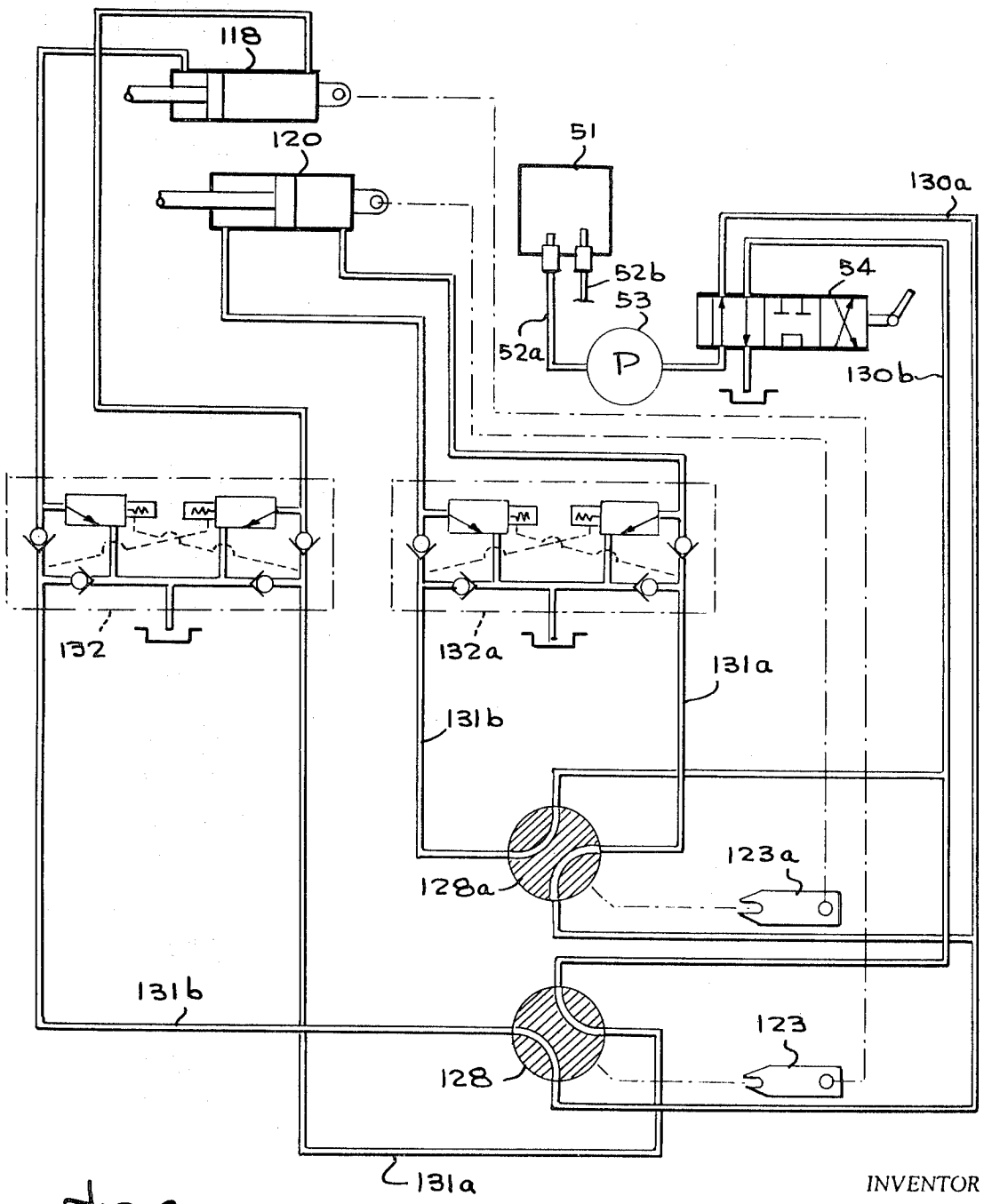

Fig-9

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BOOM STRUCTURE FOR UTILITY TRUCKS AND THE LIKE

This application is a continuation-in-part of may earlier application, Ser. No. 757,075now U.S. Pat. No. 3,533,515 filed Sept. 3, 1968.

BACKGROUND AND OBJECTS OF THE INVENTION

The present invention relates in general to boom structure for service and maintenance trucks and the like, and more particularly to an articulated boom structure having a first boom section pivotally supported at its inner end to a pedestal and a second boom section pivotally coupled at its inner end to the outer end of the first boom section and having a workman's basket or platform supported on the outer end of the second boom section.

Service and maintenance trucks employed by public utilities and similar companies are ordinarily provided with some type of boom structure pivotally supported for movement about a horizontal axis on a base or mounting structure, hereinafter generally termed a boom supporting pedestal, which is journaled on the vehicle for rotation about a vertical axis. Many of such service and maintenance trucks have employed a boom structure of the articulated type having an outer boom section pivotally coupled to the inner boom section for angular adjustment about a horizontal axis and having a worker platform or basket at the outer end of the outer boom section to support a worker at an elevated position. These structures are more commonly called "aerial towers." Such aerial towers are particularly useful in servicing overhead traffic lights, street lamps, elevated signs and similar objects.

I have heretofore disclosed in my U.S. Pat. application, Ser. No. 757,075, now U.S. Pat. No. 3,533,515 entitled BOOM STRUCTURE FOR UTILITY TRUCKS AND THE LIKE, filed on Sept. 3, 1968, a particular embodiment of a rotating drive system for driving boom structures of the articulated boom type, as well as boom structures of the telescopically extensible type, about a vertical boom pedestal axis. The drive mechanism there disclosed comprises a pair of hydraulic cylinder units arranged in angular relation to each other and coupled to a pivot tube which supports the boom assembly to drive the pivot tube and boom assembly about the vertical axis or in azimuth. There is also disclosed in said earlier application an embodiment of a novel dual hydraulic cylinder drive mechanism for driving the boom sections of an articulated boom structure in angular relation about the articulation axis.

The present application, being a continuation-in-part of said earlier application, Ser. No. 757,075 now U.S. Pat. No. 3,533,515 discloses the hydraulic cylinder drive mechanism for controlling the angular relation between the boom sections as disclosed in said earlier application, and additionally discloses another embodiment of a dual hydraulic cylinder drive mechanism for driving the outer boom section of such an articulated boom assembly about its pivotal coupling with the inner boom section, providing a more compact and structurally advantageous assembly for the intercoupled portions of the articulated boom structure.

An object of the present invention, therefore, is the provision of a novel dual hydraulic cylinder drive mechanism for driving the boom sections of an articulated boom structure in angular relation about the articulation axis, which is directly connected to the boom sections in such a manner as to continuously maintain positive control of the positions of the components driven thereby.

Another object of the present invention is the provision of a novel dual hydraulic cylinder drive mechanism for driving the outer boom section of an articulated boom assembly in angular relation about the articulation axis to the inner boom section, providing an advantageous physical arrangement of the components in the region of the articulation axis, which provides improved positive control of the angular position of the outer boom at all times, and which incorporates a four-way valve and a holding valve in a novel manner to control application of hydraulic fluid to the pair of hydraulic cylinders.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating two preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a side elevation of a utility maintenance truck having an articulated aerial tower boom structure constructed in accordance with the present invention;

FIG. 2 is a transverse vertical section view taken through the articulation assembly of the articulated boom structure, along the line 2—2 of FIG. 1;

FIG. 3 is a vertical section view of the articulation assembly taken along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary schematic fluid circuit diagram of a hydraulic control circuit controlling application of hydraulic fluid to the cylinder units of the assembly illustrated in FIGS. 2 and 3;

FIG. 5 is a fragmentary side elevation view of a modified elbow assembly of an articulated boom structure embodying the present invention;

FIG. 6 is a horizontal transverse section view taken along the line 6—6 of FIG. 5;

FIG. 7 is a vertical section view taken along the line 7—7 of FIG. 6;

FIG. 8 is an exploded perspective view of the components making up the elbow assembly of this modified embodiment; and

FIG. 9 is a schematic fluid circuit illustrating the hydraulic control circuit for the modified elbow assembly.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, wherein like reference characters designate corresponding parts throughout the several FIGS., the utility maintenance truck with which the articulated boom structure of the present invention is associated, is generally indicated at 15 in FIG. 1, the truck being equipped with a utility body 16 of conventional configuration including a driver's cab 17 and the usual rearwardly extending panel body 18 having spaced parallel sidewall sections providing, for example, a series of built-in cabinets for the storage of tools, small parts, and similar items. The sidewall sections 18' may be spaced laterally from each other and from the rear wall of the cab 17, or a front built-in cabinet wall may be disposed just rearwardly of the cab 17, defining a cargo space which is open at the top and rear. In the example illustrated in FIG. 1, the boom supporting pedestal installation is of the type commonly termed a "center mount" installation, wherein the boom supporting pedestal structure is mounted within the open area between the sidewall sections 18' immediately overlying the rear axle.

The boom pedestal assembly may be of any known construction, the pedestal assembly herein illustrated being of the type disclosed more fully in my earlier U.S. Pat. application, Ser. No. 757,075, now U.S. Pat. No. 3,533,515 filed Sept. 3, 1968. The boom pedestal assembly is generally indicated by the reference character 19, and supports a head structure 20 which is here illustrated as containing lobe portions 21 for receiving a horizontal pivot shaft 21' to pivotally couple the boom structure, generally indicated at 22, to the head structure 20 at points spaced laterally from the extended vertical axis through the pedestal assembly 19. The boom structure 22 comprises a main or inner boom section 23 having its inner end coupled to the pivot shaft 21' and having an articulation assembly 24 at its outer end forming a pivot coupling with the outer boom section 25. The outer boom section 25 has the usual worker's platforms or baskets 26 pivotally mounted on the free or outer end of the boom section 25. The inner or main boom section 23 is powered for vertical angular movement about the axis of the horizontal pivot shaft 21' in a conventional manner, as by the hydraulic cylinder unit 27 having a cylinder and a movable piston rod, one of which is coupled

to the head structure 20 and the other of which is coupled to the inner boom section 23.

The boom pedestal assembly 19 may comprise a transmission housing 30 of horizontally elongated, generally rectangular configuration supported in nested relation between a pair of spaced mounting assemblies 32 on transverse I-beams 33 fixed on the top of the frame rails 34 of the truck chassis, and having a rotary power head 31 projecting from the top of the housing 30, enclosing a vertical hollow pivot tube or pedestal shaft rotatable about a substantially vertical axis and driven by a pair of double acting hydraulic cylinder units having circular drive rings surrounding eccentric cams on the pivot tube for rotating the same, all as described in said earlier copending application. Alternatively, any other known rotating drive system for driving the boom assembly about the vertical boom pedestal axis may be employed, such as any of the well-known cylinder and chain drive mechanisms, the well-known cylinder and cable drive mechanisms, or any of the known gear train mechanisms.

The articulation assembly 24 providing the pivotal coupling between the inner or main boom section 23 and the outer boom section 25 is provided with a dual hydraulic cylinder drive mechanism for driving the boom sections to regulate their angular relation about the articulation axis and continuously maintaining positive control of the relative angular positions of the inner and outer boom sections at all times. The articulation assembly 24, shown more clearly in FIGS. 2 and 3, comprises a pivot shaft 40 extending through both the inner boom 23 and the outer boom 25 adjacent the outermost end of the former, defining the common pivot axis for the articulation joint. A sleeve 41 surrounds the pivot shaft 40 and is freely rotatable thereon, and is journaled for free rotation in bushing segments 42 of the respective booms 23, 25. Sprockets 43 disposed within the hollow booms 23 and 25 and fixed to the sleeve 41 are provided for the chain sprocket-type basket-leveling system, which may be of conventional construction of forms no part of the present invention. A first double acting hydraulic cylinder 44 is provided between the two booms 23, 24, having its end remote from the pivot shaft 40 pivotally connected to the main boom 23 and having a piston rod 44*a* pivotally coupled, as indicated at 45*a*, to a first crank member in the form of a knuckle lever 45 rotatably journaled on the sleeve 41 between the two boom sections and secured to the outer boom section 25, as by welds 46. A second double acting hydraulic cylinder 47 is also pivotally secured to the inner boom section 23 at 47' at its end remote from the axis of the pivot shaft 40, for example, on an axis common with the axis of the pivot at which the cylinder 44 is secured to the boom section 23, and has a piston rod 47*a* pivotally coupled to a second crank member in the form of knuckle lever 48 outboard of the main boom section 23, which is fixed to the end of the pivot shaft 40. The pivot shaft 40 is also secured to the outer boom section 25, as by weld 49 at the end thereof opposite the cylinder 47. The two knuckle levers 45 and 48 are disposed in substantially 90 relation to each other, forming respectively eccentric crank members secured to the outer boom section 25 and to the pivot shaft 40, with the axes of the cylinders 44, 47 disposed in angular relation to each other.

The purpose of this arrangement of the knuckle levers and cylinders in angular relation to each other is to insure that one of the cylinders, and its associated knuckle lever, is at a favorable position to provide power and leverage for swinging the outer boom section 25 about the axis of the pivot shaft 40 whenever the piston rod of the other cylinder is in a dead center position. For example, if the piston rod 44*a* has been retracted from the position illustrated in FIG. 3, to a position disposing the longitudinal axis of the piston rod 44*a* in exact alignment with the center axis of the pivot shaft 40, the knuckle lever 48 will be in the approximately 6 o'clock position, as viewed in FIG. 3, thus providing adequate leverage for rotating the outer boom 25 when the piston rod 44*a* is in its unfavorable leverage position. By this construction, reliable control of the angular position of the outer boom section 25 relative to the inner boom section 23 is insured through an angular range of approximately 270°.

One form of hydraulic control circuit which may be used to control the flow of fluid to the hydraulic cylinders 44, 47, and thereby control the angular movement of the boom section 25 about the articulation joint at shaft 40 is illustrated schematically in FIG. 4. In this embodiment of the control circuit for regulating angular movement of the boom sections about the articulation axis at shaft 40, a hydraulic fluid reservoir 51 for the control system has hydraulic fluid supply and return hoses 52*a* and 52*b*, the supply hose 52*a* being coupled to the inlet of a suitable pump 53, the outlet of which supplies the hydraulic fluid under pressure to a manually operable master control valve 54 located, for example, on the basket for operation by the occupant of the basket. If desired, another like master control valve (not shown) may be provided on the pedestal connected in parallel with the master control valve 54. The control ports of the control valve 54 are connected through manifold lines indicated by reference characters 55*a* and 55*b* and cam actuated reciprocating pilot valves 56 and 57 to hydraulic control lines 58*a* and *b* to the hydraulic cylinder 44 and 59*a* and *b* to the hydraulic cylinder 47. The movable valve members of the pilot valves 56 and 57 are controlled by a pair of sector cams 60, 61, fixed to the respective cylinders 44, 47, for example, as extensions from the pivoted ends of the respective cylinders, to continuously monitor the angular positions of their respective cylinders. The pilot valves 56 and 57 are adjusted by the sector cams 60, 61, as the latter rock with their associated cylinders about the pivots 44', 47', so as to reverse the fluid connections to their associated cylinders 44, 47, when they reach the dead center positions with respect to the axis of the shaft 40 and to regulate direction of fluid flow to the cylinders to advance or retract their piston rods so as to achieve proper rotation of the knuckle levers 45 and 48. The profile configuration of the working surface of each of the sector cams 60, 61, is substantially that illustrated in FIG. 4, and includes a short step or dwell portion at the transition from the largest raised portion to the smaller radius portion, during which the associated pilot valve 56, 57, is held in a neutral position to avoid interference of the cylinder which is in the dead center position with the action of the other cylinder.

Although the control lines 58*a* and *b* and 59*a* and *b* can be directly connected to the pilot valves 56, 57, in the preferred embodiment illustrated in FIG. 4, pilot operated check valves 62, 63 are interposed between the pilot valves 56, 57, and their respective associated cylinders 44, 47. These valves 62, 63, are, for example, of the construction of the Motion Control and Lock Valve manufactured by Fluid Controls, Inc. of Mentor, Ohio, designated Model 1EEC11and 1EEC12, having check valves and relief valves including pilot override pistons, connected as indicated schematically in FIG. 4. The relief valves are set, as is well known to those skilled in the art, to open at a pressure slightly greater than the maximum pressure which the load can exert at any time, so that positive pump pressure is always required to move the piston of the associated cylinder and the load will be instantly locked when pump flow is stopped. These pilot operated check valves 62, 63 serve as a holding valve to lock the outer boom section at any angular position without drift, provide overload protection, provide volumetric control permitting spill-off and/or makeup of oil in the associated cylinder when required, preventing angular movement of the boom from overrunning the pump, relieve excess pressures which build up due to thermal expansion, and provide smooth acceleration and deceleration by relieving surges caused by sudden shifting of the control valve.

Assuming the fluid controls to be in the positions illustrated in FIG. 4, and the knuckle levers 45, 48 to be in the position shown in FIG. 3, hydraulic fluid will be withdrawn from the reservoir 51 through the line 52*a* by the pump 53 and discharged therefrom through the control valve 54 to the pilot valves 56, 57. The follower of the pilot valve 56, being on the high portion of the sector cam 60, connects the inlet and out-

let ports to transmit hydraulic fluid through the valve 62 to the control line 58*a* and cylinder 44, causing the cylinder 44 to retract its piston rod to the right as viewed in FIG. 4, and thus rotating the knuckle lever 45 in a clockwise direction from the position shown in FIG. 3. Simultaneously, the pilot valve 57 is riding on the low portion of the sector cam 61, and thus cross-connects its inlet and outlet ports to apply hydraulic fluid through the valve 63 and conduit 59*a* to the cylinder 47 to progressively extend its piston rod 47*a* and thus rotate the knuckle lever 48 in a clockwise direction from the position shown in FIG. 3. When the knuckle lever 48 reaches the dead center position, the follower of the pilot valve 57 reaches the step or swell between the high and low portion of the sector cam 61, shifting the pilot valve 57 to neutral position to place the cylinder unit 47 in floating condition. At this time, the cam follower of pilot valve 56 is still on the high portion of the sector cam 60 and the knuckle lever 45 is in approximately the 6 o'clock position as viewed in FIG. 3, thus providing a favorable moment art for positive control of the position of the outer boom section 25 by the knuckle lever 45 and cylinder 44. As rotation of the outer boom 25 continues in the clockwise direction as viewed in FIG. 3, the first knuckle lever 45 then reaches the 9 o'clock position wherein the shaft 40 is along the extended axis of the piston rod 44*a*. At this 9 o'clock position of the knuckle lever 45, the follower of the pilot valve 56 rides onto the dwell or step between the high and low portions of the section cam 60, shifting the pilot valve 56 to the neutral position to place the cylinder unit 44 in floating condition. Concurrently, the second knuckle lever 48 is in approximately the 6 o'clock position, thus again providing a favorable moment arm for controlling the angular position of the outer boom section 25, this time by the cylinder unit 47. When it is desired to stop rotation of the outer boom section 25, the control valve 54 is manually adjusted to the neutral position, terminating the supply of hydraulic fluid to the cylinder units 44 and 47 and holding them in the positions which they occupied. Of course, upon movement of the control valve 54, to the reverse position, reverse actuation of the cylinder units 44, 47, from what was previously described will occur, causing the outer boom section 25 to rotate in the counterclockwise direction as viewed in FIG. 3.

A modified form of elbow assembly for the articulated boom structure is illustrated in FIGS. 5 to 9 inclusive. Referring to FIGS. 5 to 9, the lower or main boom section is indicated by the reference character 23, and except for the articulation assembly or elbow assembly portion, may be of the same construction as the main boom section of the previously described embodiment, and the upper or outer boom section is indicated by the reference character 25, and, except for the elbow assembly portion, corresponds to the outer boom section of the previously described embodiment. The elbow assembly of the embodiment of FIGS. 5 to 9 is indicated by the reference character 101, and includes a cover or housing 102 including a first inboard vertical side plate 103, a second outboard vertical side plate 104, and a vertical center partition plate 105, together with bottom and top plate portions 106A and 106B, and a curved end plate portion 106C having a removable access cover portion 106C'. The inner end portion of the housing 102 is of narrower transverse dimensions than the remaining portion, and is reinforced by channel members and internal reinforcing plates indicated generally at 107, to be inserted into the outer end of the lower boom member 23 and fixed thereto, for example, by bolts extending through mounting shoulders formed by the plates 108 at the transition portions between the side plates 103 and 104 and the narrower inner end portion of the housing 102. The plates 108 butt similar plates on the outer end of the boom section 23 and are readily bolted thereto, thus permitting the elbow assembly as a whole to be readily removed and replaced.

The center partition plate 105 and the inboard side plate 103 are provided respectively with an outboard bushing 110 and an inboard bushing 111. The outboard bushing 110 has an inner cylindrical surface appropriate to rotatably receive and support the cylindrical boss portion 112*a* of outboard crank member 112 which has a cylindrical bore sized to receive the pivot shaft 113 therethrough. The end portion of the pivot shaft 113 lying within the bore of the crank member 112 is keyed to the crank member by keys, one of which is shown at 112*b*, extending into kerfs in confronting surface portions of the shaft and the bore of the crank member, and the shaft extends through a similar bore in an inboard crank member 114 to which the shaft 113 is also keyed against relative rotation by keys 114*b* entering kerfs in the shaft 113 and in the surface of the bore in the cylindrical portion 114*a* of the crank member 114. The shaft 113 also extends through the smooth surfaced cylindrical bore of the inboard bushing 111 and into a bore in the sleeve 115 fixed in the housing or cover 116 of similar external configuration to the housing 102 and secured at its smaller end to the upper boom section 25. The end portion of the shaft 113 lying in the sleeve 115 is also keyed to the sleeve by keys fitting into kerfs in the surface of the bore of the sleeve 115 and in the surface of the pivot shaft 113 in a manner similar to the key couplings between the shaft 113 and the crank members 112 and 114. The sleeve 115 can be welded in the housing 116 at whatever angle the customer wants, and thereby affords considerable flexibility in manufacture of the units with the upper boom section 25 having a number of different lower or rest positions.

A first double acting hydraulic cylinder 118 is provided between the center partition plate 105 and the outboard side plate 104 and is pivotally supported at its end remote from the pivot shaft 113 by cylinder pivot pin 119 passing through the center partition plate 105, and having a piston rod 118*a* pivotally coupled as indicated at 118*a*' to the lever arm 112*c* of the crank member 112. Similarly, a second double acting hydraulic cylinder 120 is pivotally mounted at its end remote from the pivot shaft 113 on the pin 119, and has a piston rod 120*a* pivotally coupled as indicated at 120*a*' to the lever arm portion 114*c* of the inboard crank member 114. The lever arm portions 112*c* and 114*c* of the outboard crank member 112 and inboard crank member 114 are disposed in substantially ninety degree relation to each other, forming respectively eccentric crank members which are secured to the outer boom by virtue of their keyed couplings to the shaft 113, with the axes of the two cylinder units 118 and 120 disposed in angular relation to each other.

The purpose of this arrangement of the lever arm portions of the crank members 112 and 114 and the cylinders 118 and 120 in angular relation to each other is to insure that one of the cylinders and its associated crank member is at a favorable position to provide power and leverage for swinging the upper boom section 25 about the axis of the pivot shaft 113 whenever the piston rod of the other cylinder is in a dead center position.

A valve actuator assembly is provided as an extension on the pivoted ends of each of the cylinders 118 and 120, formed for example of a yoke type supporting bracket 122, 122*a* fixed as by suitable bolts to the ears on the ends of the cylinders 118, 120, the brackets having a valve actuator member 123, 123*a* rigid with and extending from the brackets 122, 122*a* each having a slot in the free end thereof in which is fitted the head of a bolt or similar formation 124' forming a bearing head on the free end portion of a valve spool control lever 124, the opposite end of which has a circular opening 124*a* therein to receive an end of a rotatable valve spool 126 rotatable in the valve block 127 of respective control valves 128, 128*a* regulating the flow of hydraulic fluid to the cylinders 118, 120. The end portion of the valve spool control lever 124 having the opening 124*a* therein is split from the opening through the adjacent end of the lever and provided with a clamping volt 124*b* therethrough to facilitate assembly and removal of the control lever relative to the valve spool 126, and as an additional feature to obtain final micrometer adjustment of the angular relation of the lever 124 relative to the valve spool 126, a pair of Allen head-type screws 124*c* extend through tapped openings through a lateral edge of the lever

124 into the spool opening 124*a* to abut portions of the flat 126*a* on the end of the valve spool 126 near the juncture of the flat with the cylindrical surface of the valve spool.

The valve body blocks 127 of the cylinder control valve 128, 128*a* may each be conveniently mounted on the center partition plate 105 in any desired manner, such as by a valve mounting bracket 129 secured by bolts to the valve body and to the reinforced portion 107 of the center partition plate, and are each preferably of the same construction as the leveling control valve 38 described in detail in my copending application Ser. No. 10,469 filed Feb. 10, 1970 and entitled BASKET LEVELING SYSTEM FOR BOOM STRUCTURES. As disclosed in that earlier application, the valve body is generally in the form of a rectangular block having a cylindrical bore extending entirely therethrough sized closely to the diameter of the valve spool to rotatably accommodate the spool, and the spool is of generally cylindrical configuration having a longer axial length than the length of the bore in the valve body block to provide an exterior end portion, which in the present application has the flat 126*a* thereon, the end portion to be coupled in the opening 126 of the valve spool control levers 124. Each valve spool 126, like the valve spool disclosed in said earlier application, has a pair of annular distribution/collector grooves in the form of fluid conveying circumferential channels in planes perpendicular to the axis of the spool which are aligned with and in continuous communication with inlet ports drilled in the valve body 127 of each valve connected to the supply conduits, such as indicated at 130*a*, 130*b*, in this application, extending to a source of hydraulic fluid. The spool of each of these valves 128, 128*a* is sealed against leakage outwardly of the previously mentioned circumferential grooves, and has ports and branch conduits drilled therein providing diametrical through ports communicating with the two distribution/collector grooves and arranged along mutually perpendicular axes extending normal to the axis of rotation of the spool, as well as outlet port openings in the spool which are to be selectively aligned with outlet port networks in the valve body connected by fluid conduits 131*a*, 131*b*to the advance and retract fluid conduit connections to the respective hydraulic cylinders 118, 120.

The control valves 128, 128*a* correspond substantially in their control functions to the valves 56, 57 in the previously described embodiment, and the fluid conduits 131*a*, 131*b* between these valves and their respective cylinders, diagrammatically illustrated in FIG. 9, include holding valves 132, 132*a* corresponding to the pilot operated check valves 62, 63 in the first described embodiment. These holding valves 132, 132*a* are also supported on suitable mounting brackets on the center partition 105, and like the valves 62, 63, may be of the construction of the Motion Control and Lock Valve manufactured by Fluid Controls, Inc. of Mentor, Ohio, designated Model 1EEC11and 1EEC12, having check valves and relief valves including pilot override pistons. The relief valves are set, as is well known to those skilled in the art, to open at a pressure slightly greater than the maximum pressure which the load can exert at any time, so that positive pump pressure is always required to move the piston of the associated cylinders 118, 120 and the load will be instantly locked when pump flow is stopped. These pilot operated holding valves 132, 132*a* serve to lock the outer boom section at any angular position without drift, provide overload protection, provide volumetric control permitting spill-off and makeup of oil in the associated cylinders when required, preventing angular movement of the upper boom section relative to the lower boom section from overrunning the pump, relieve excess pressures which build up due to thermal expansion, and provide smooth acceleration and deceleration by relieving surges caused by sudden drifting of the control valve. They enhance the ability to go through the center position, and provide a significant safety factor, since if one of the cylinders fails when the other is at dead center position, the holding valves allow drift to permit a sag of the boom section 15° (to 3,000 p.s.i.) and then hold. In this way, the elbow assembly is protected against a one cylinder failure which would leave the upper boom supported only by a cylinder in dead center position.

In the particular structural assembly illustrated in FIG. 8, the inboard and outboard side plates 103, 104 are provided with openings affording access to the valves and valve actuating members, and have a socket plate 134 fixed to the side plates and spanning a portion of these access openings to provide supports for the opposite ends of the pivot pin 119, these openings being normally covered by removable access covers 135, 135*a*.

A form of hydraulic control circuit which may be used to control the flow of fluid to the hydraulic cylinders 118 and 120, and thereby control the angular movement of the boom section 25 about the elbow assembly axis at shaft 113, is illustrated schematically in FIG. 9. In the schematic diagram of FIG. 9, those components which correspond to the components of the hydraulic circuit of the first embodiment illustrated in FIG. 4 are identified by the same reference characters as employed in FIG. 4. In this control circuit, the hydraulic fluid reservoir 51 has hydraulic fluid supply and return hoses 52*a* and 52*b*, the supply hose being coupled to the inlet of a suitable pump 53, the outlet of which supplies the hydraulic fluid under pressure to a manually operable control valve 54. The control ports of the control valve 54 are connected through manifold lines indicated by reference characters 130*a* and 130*b* and the control valves 128, 128*a* controlled by the valve actuators 123, to hydraulic control lines 131*a*, 131*b* to the cylinders 118, 120. The rotatable spools 126 of the control valves 128, 128*a* are controlled by the valve actuators 123 fixed to the cylinders 118, 120, the mechanical connections being indicated by broken lines in FIG. 9. These control valves 128, 128*a* are adjusted by the valve actuators 123 as they rock about their associated pivots so as to reverse the fluid connections to their associated cylinders 118, 120 when they reach the dead center positions with respect to the axis of the shaft 113 and to regulate direction of fluid flow to the cylinders to advance or retract their piston rods so as to achieve proper rotation of the crank members 112, 114. The pilot operated check valves forming holding valves 132, 132*a* which were previously described, are illustrated schematically in FIG. 9 interposed in the fluid conduits 131*a*, 131*b* between the control valves and their respective hydraulic cylinders. The functions of the control valves 128, 128*a* and the valve actuators 123 are to affect the same type of control as was described in connection with the embodiment of FIGS. 1 to 4, so that at least one of the crank members 112, 114 is in a favorable moment arm position when the other crank member is substantially at dead center position so that there is always effective positive control of the position of the outer boom section 25.

What is claimed is:

1. In an articulated boom structure for utility vehicles and the like including a first boom section having an inner end supported for movement in azimuth about a vertical axis and for vertical angular movement about a horizontal axis and having an outer end, a second boom section pivotally connected at a first end thereof to the outer end of said first boom section for vertical angular movement relative to said first boom section about a horizontal articulation axis; the improvement comprising power means for driving said second boom section relative to said first boom section about said articulation axis comprising a pivot shaft coaxial with said articulation axis extending through both said boom sections and fixed to said second boom section against rotation relative to the latter, means journaling said pivot shaft for rotation in said first boom section, a pair of crank members defining lever arms coupled to said pivot shaft against rotation relative thereto extending along different radii of said shaft and defining a substantial angle therebetween, and a pair of axially extensible hydraulic cylinder units each having a pivoted end mounted on said first boom section and a movable working end respectively coupled to said lever arms eccentrically of said pivot shaft to rotate said pivot shaft and second boom section about said articulation axis.

2. An articulated boom structure as defined in claim 1, wherein one of said crank members is located between said boom sections and the other crank member is located on the opposite side of said first boom section from said second boom section.

3. An articulated boom structure as defined in claim 1, wherein said lever arms extend along radii of said pivot shaft defining an angle of about 90° therebetween.

4. An articulated boom structure as defined in claim 2, wherein said lever arms extend along radii of said pivot shaft defining an angle of about 90° therebetween.

5. An articulated boom structure as defined in claim 1, wherein said cylinder units are coupled to said lever arms at eccentric coupling points spaced sufficiently far from said shaft to provide a range of at least about 270° rotation of said second boom section relative to said first boom section.

6. An articulated boom structure as defined in claim 3, wherein said cylinder units are coupled to said lever arms at eccentric coupling points spaced sufficiently far from said shaft to provide a range of at least about 270° rotation of said second boom section relative to said first boom section.

7. A boom structure as defined in claim 1, including valve control members rotatable about the pivot axes of the pivoted ends of said cylinder units and driven in continuously coordinated relation to the angular positions of said cylinder units and lever arms, and valve means controlled by said control members for automatically reversing flow of hydraulic fluid to said cylinder units when their extension axes pass through dead center positions relative to said articulation axis.

8. A boom structure as defined in claim 7, wherein said valve means for each of said control members comprises a rotatable valve spool movable angularly in a valve body from a neutral position to first and second positions establishing forward and reverse flow of hydraulic fluid to the associated cylinder unit, an actuating lever coupled to each respective valve spool, and means coupling the actuating levers to the respective valve control members.

9. A boom structure as defined in claim 8, wherein said last mentioned means comprises a head formation on each actuating lever eccentric of the valve spool axis and said control members each having a slot slidably receiving the associated head formation for angularly moving the levers in selectively coordinated relation to angular movement of the cylinder units about their pivoted ends.

10. A boom structure as defined in claim 6, including valve controlling cam members driven in continuously coordinated relation to the angular positions of said cylinder units and lever arms, and valve means controlled by said cam members for automatically reversing flow of hydraulic fluid to said cylinder units when their extension axes pass through dead center positions relative to said articulation axis.

11. A boom structure as defined in claim 1, including a housing on the end of said first boom section adjacent said articulation axis having a vertical center partition and first and second sidewalls spaced from said partition, one of said crank members and its associated cylinder units being located wholly in said housing, between said partition and said first sidewall, and the other crank member and its associated cylinder unit being located within said housing between said partition and the second sidewall, and said partition and one of said sidewalls having bearing bushing means rotatably supporting said pivot shaft therein.

12. An articulated boom structure as defined in claim 11, wherein said lever arms extend along radii of said pivot shaft defining an angle of about 90° therebetween.

13. An articulated boom structure as defined in claim 12, wherein said cylinder units are coupled to said lever arms at eccentric coupling points spaced sufficiently far from said shaft to provide a range of at least about 270° rotation of said second boom section relative to said first boom section.

14. A boom structure as defined in claim 11, including valve control members rotatable about the pivot axes of the pivoted ends of said cylinder units and driven in continuously coordinated relation to the angular positions of said cylinder units and lever arms, and valve means controlled by said control members for automatically reversing flow of hydraulic fluid to said cylinder units when their extension axes pass through dead center positions relative to said articulation axis.

15. A boom structure as defined in claim 14, wherein said valve means for each of said control members comprises a rotatable valve spool movable angularly in a valve body from a neutral position to first and second positions establishing forward and reverse flow of hydraulic fluid to the associated cylinder unit, an actuating lever coupled to each respective valve spool, and means coupling the actuating levers to the respective valve control members.

16. A boom structure as defined in claim 15, wherein said last mentioned means comprises a head formation on each actuating lever eccentric of the valve spool axis and said control members each having a slot slidably receiving the associated head formation for angularly moving the levers in selectively coordinated relation to angular movement of the cylinder units about their pivoted ends.