

May 12, 1964

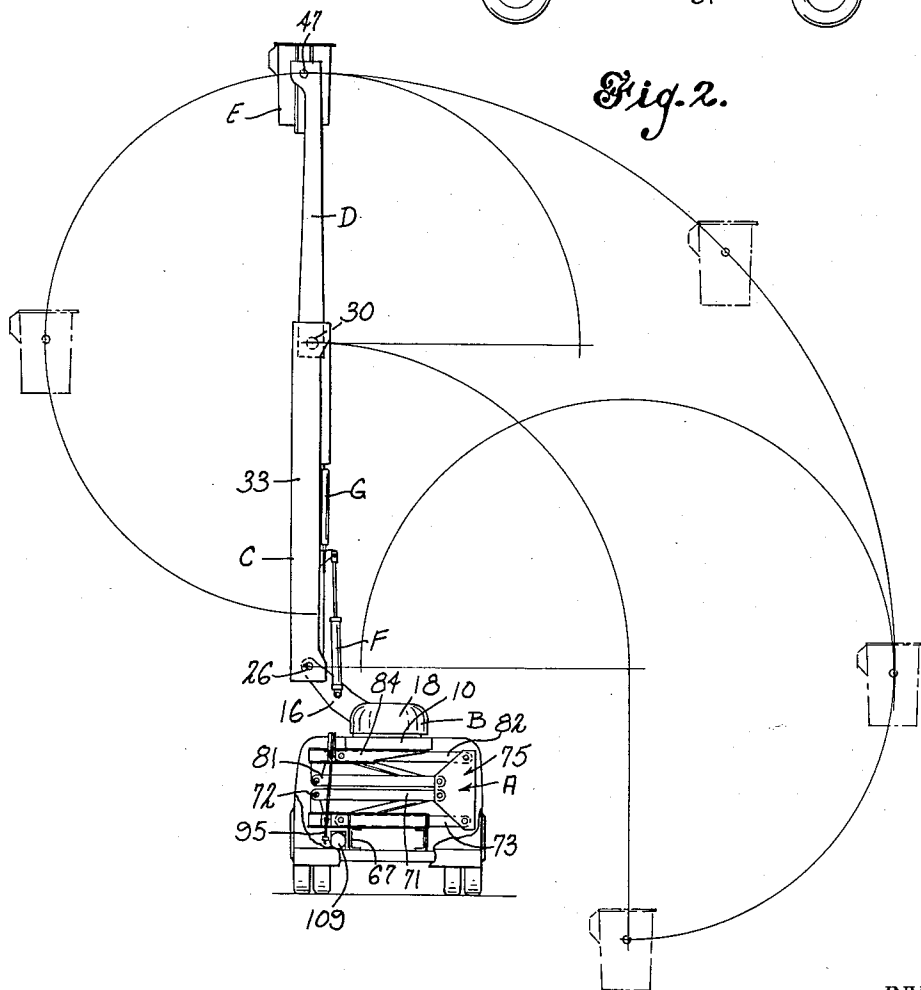
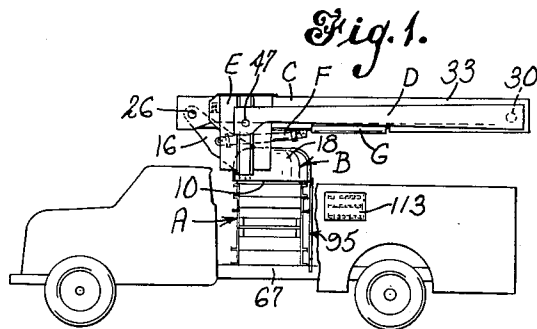
W. M. PIERCE, JR

3,132,718

POWER-OPERATED BOOM STRUCTURE

Filed April 27, 1960

7 Sheets-Sheet 1



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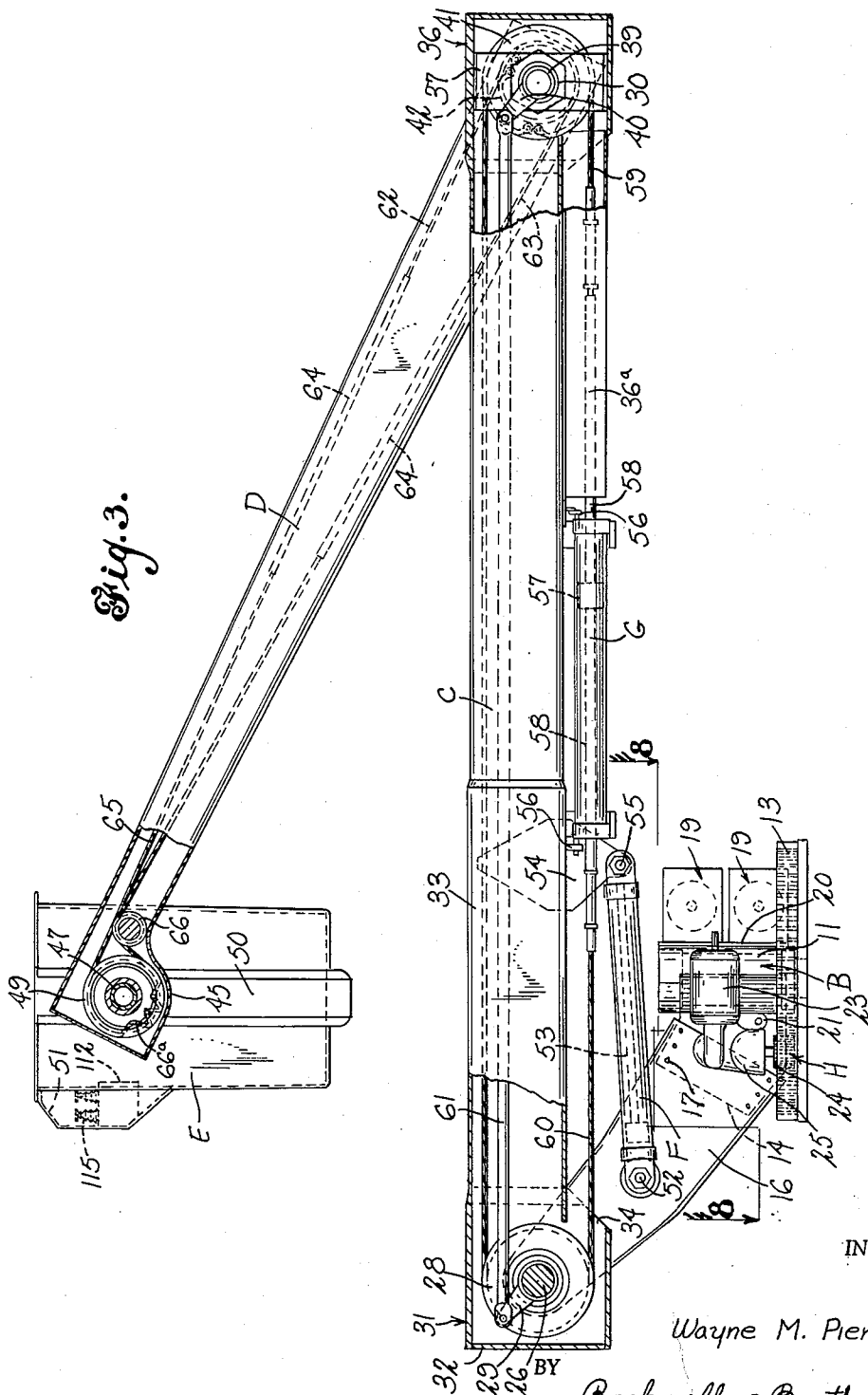
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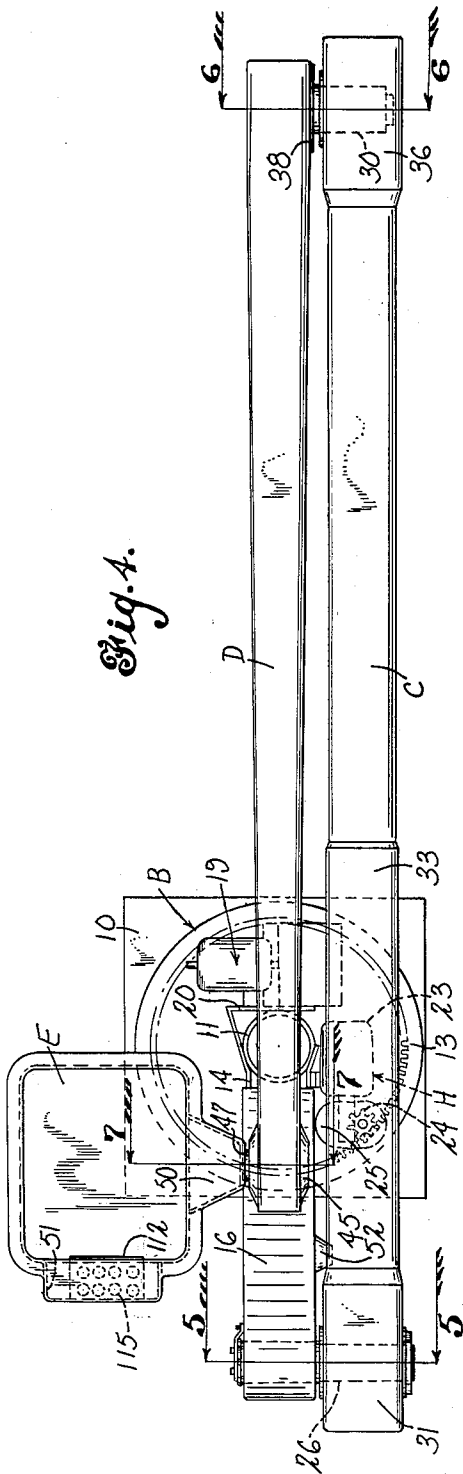


Fig. 4.

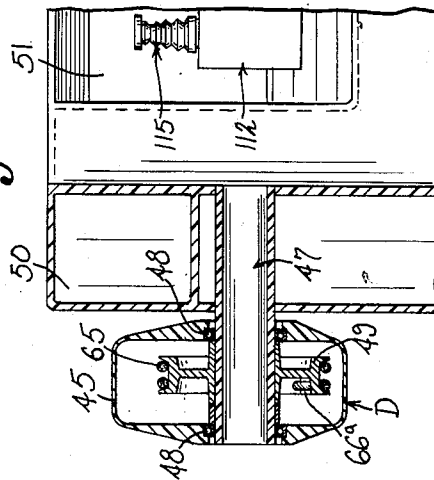
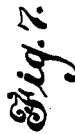


Fig. 6.

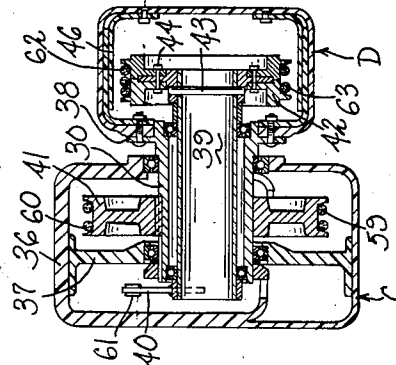
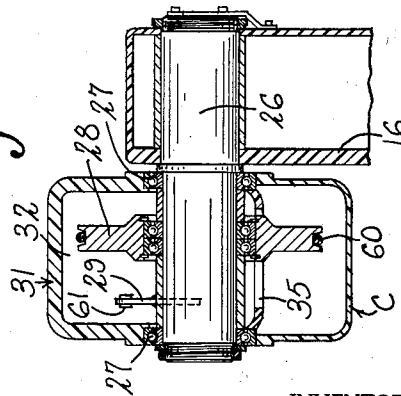


Fig. 5.



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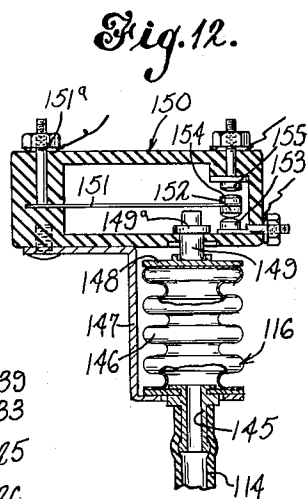
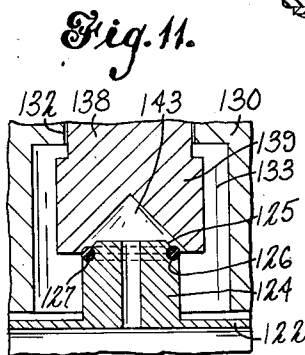
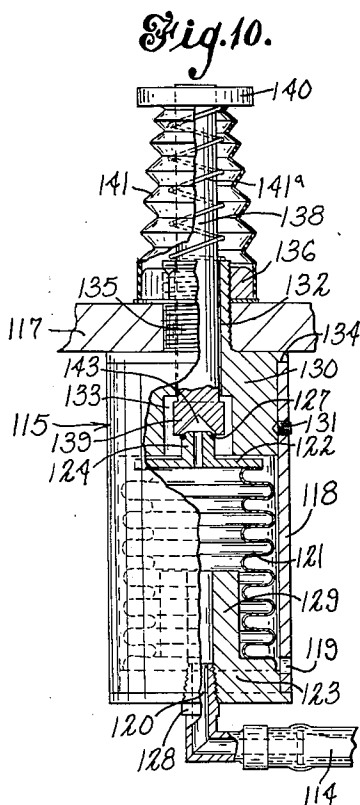
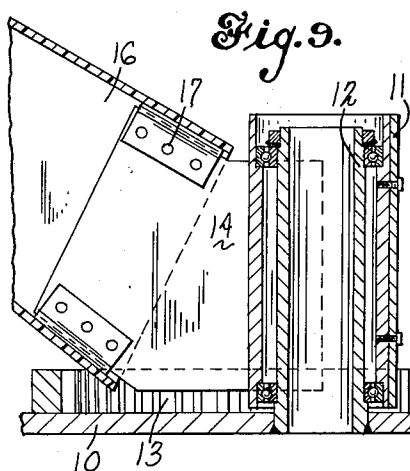
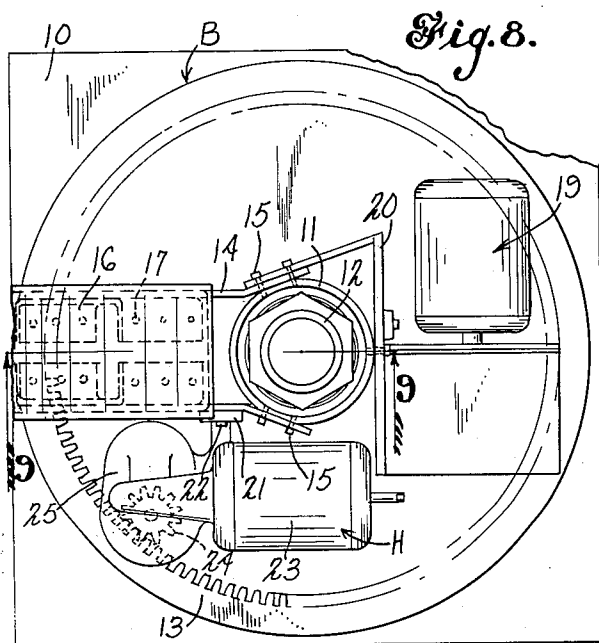
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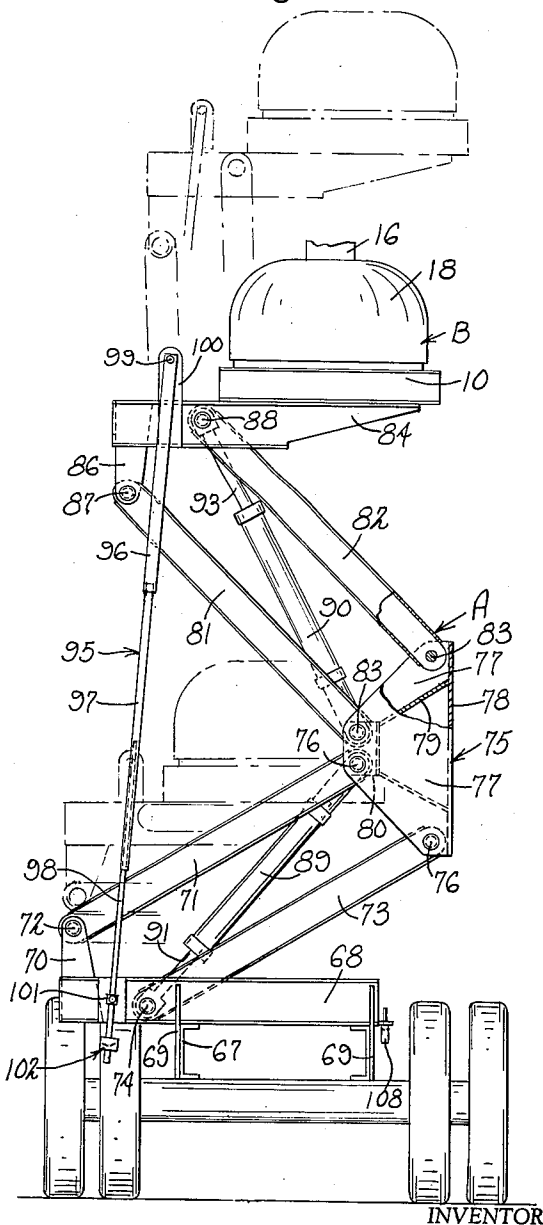
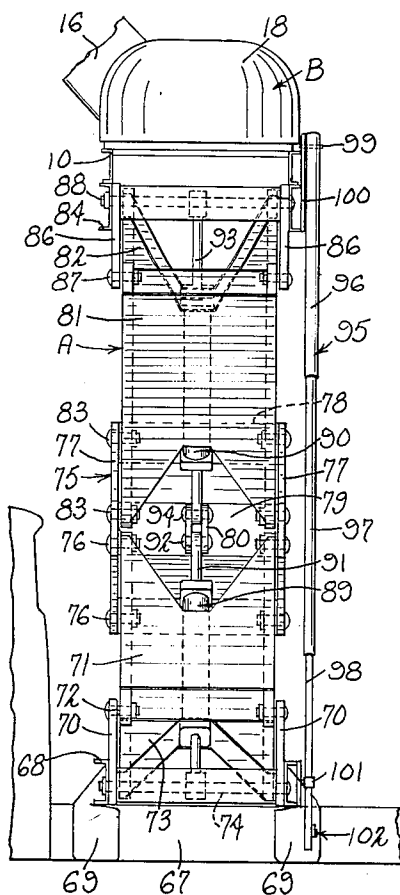
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Fig. 14.

Fig. 13.



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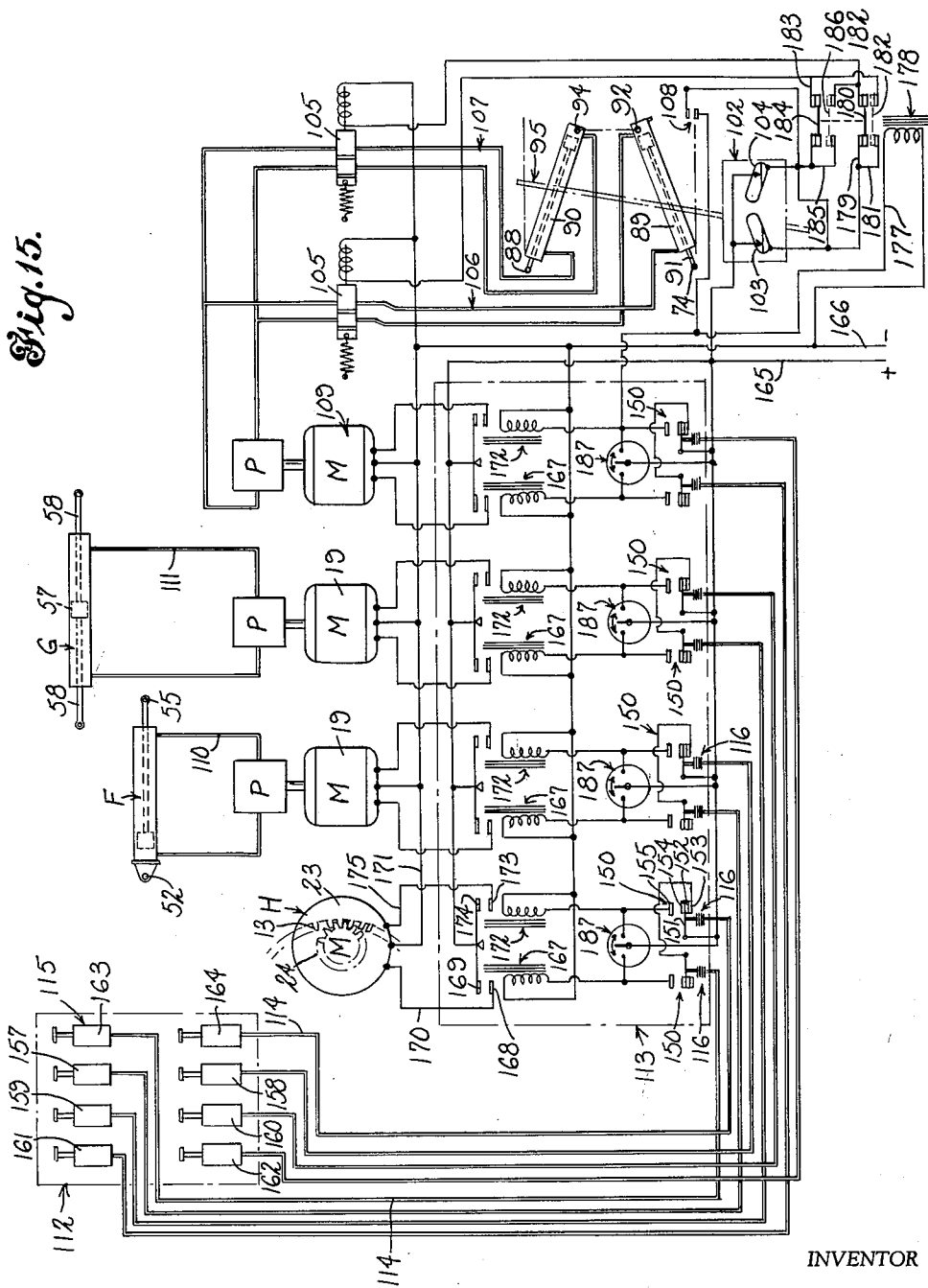
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Fig. 15.



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Fig. 16.

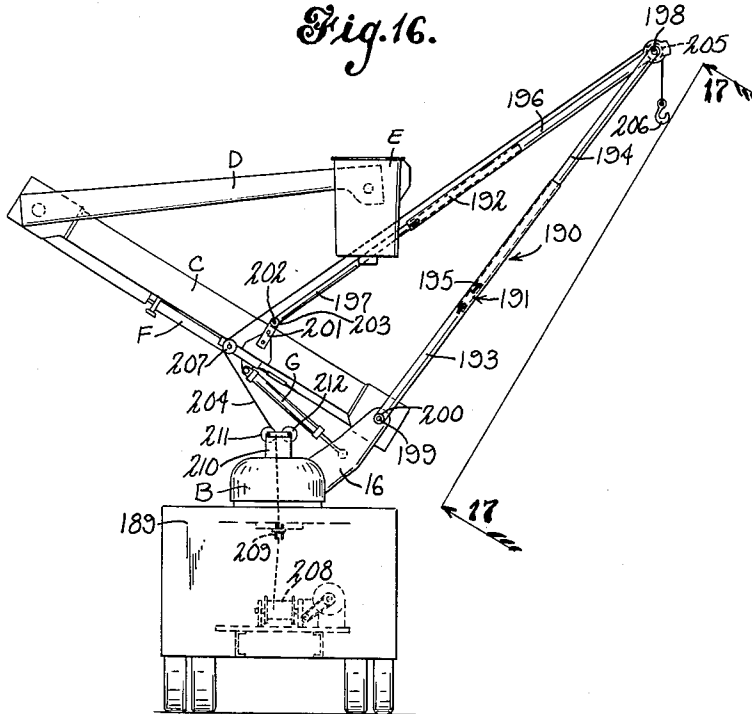
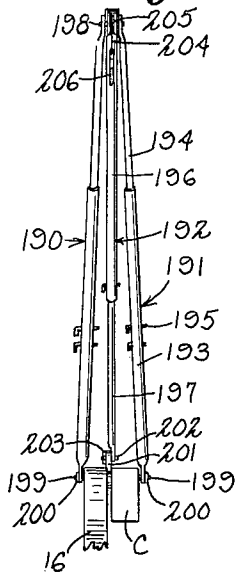


Fig. 17.



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POWER-OPERATED BOOM STRUCTURE

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Filed Apr. 27, 1960, Ser. No. 24,955

5 Claims. (Cl. 182-63)

This invention relates to articulated boom structures, and relates more particularly to boom structures, usually carried by trucks, of the type that raise and support a workman a distance above the ground. Such structures have been found useful for many purposes. For example, they have been employed in the cutting of high tree limbs and for the construction and maintenance of overhead electrical lines and allied equipment.

Overhead lines often carry high voltages which present a hazard to workmen and others near workmen. Heretofore, in the use of such equipment, difficulty has been encountered in protecting linemen from severe, and sometimes fatal, shocks from high voltage electrical lines of the overhead type.

Another difficulty that has been encountered in the past is that these boom structures, when constructed to reach substantial heights, have a tendency to tip their supports, such as trucks, by their weight when they are extended. Obviously, this tendency may be a dangerous one for workmen unless proper provisions are made to stabilize the trucks. The use of long boom sections in an articulated boom structure to attain substantial heights has not only resulted in a problem in connection with the stowage of these sections on a truck, but has required, in many instances, the use of a heavy truck or a truck provided with stabilizing outriggers which may be used only when the truck is stationary.

One object of the invention is to provide an improved articulated boom structure for carrying workmen aloft, which is particularly well suited for support on a truck for transport from place to place.

A further object is to provide a boom structure having a very high degree of safety in use, especially safety with respect to electrical shock hazards.

Still another object is to provide a boom structure which has great stability in use and which, while being able to support a workman at a substantial height, may be supported on a relatively light truck and may be supported from the truck without the use of truck outriggers to act as stabilizers.

A further object is to provide a boom structure, such as characterized above, the parts of which may be folded and easily stowed on a truck.

Another object of the invention is to provide improved means for effecting movements of the parts of a boom structure such as characterized above.

In the accompanying drawings:

FIG. 1 is a broken side elevational view of a truck carrying a boom structure embodying the invention, the boom structure being shown in folded condition;

FIG. 2 is a rear elevational view of the truck illustrating the upper boom sections in extended condition and showing the amplitude of swinging movements obtainable in the boom structure;

FIG. 3 is an enlarged elevational view of the boom structure in partially unfolded condition, the structure being partially broken away to better illustrate certain elements;

FIG. 4 is a top plan view of the boom structure;

FIG. 5 is an enlarged sectional view taken on line 5-5 of FIG. 4;

FIG. 6 is an enlarged sectional view taken on line 6-6 of FIG. 4;

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FIG. 7 is an enlarged sectional view taken on line 7-7 of FIG. 4;

FIG. 8 is an enlarged sectional view taken on line 8-8 of FIG. 3;

FIG. 9 is a sectional view taken on line 9-9 of FIG. 8;

FIG. 10 is an elevational view partially broken away, illustrating one of the pneumatic control mechanisms employed in the boom structure;

FIG. 11 is a fragmentary view on a larger scale and taken in the same plane as FIG. 10, better illustrating certain parts of the control mechanism, shown in FIG. 10;

FIG. 12 is a sectional view of a slave unit operated by the control mechanism of FIG. 10;

FIG. 13 is a fragmentary view illustrating in side elevation certain elements of the boom structure in extended positions, looking from one side of the truck;

FIG. 14 is a view of the same elements in extended positions, looking from the rear of the truck;

FIG. 15 is a schematic view, illustrating electrical and hydraulic elements which operate the boom structure;

FIG. 16 is an elevational view of a truck-carried boom structure of modified form and equipped with an auxiliary boom attachment; and

FIG. 17 is a view of the boom attachment, looking in the direction of arrows 17 in FIG. 16.

In the form of the truck-mounted boom structure, shown in FIGS. 1 through 15, the base portion of the boom structure is indicated generally at A; a turret, mounted on the top of the base portion for swiveling movement on a vertical axis, is indicated generally at B; a lower boom section, pivotally mounted on the turret for vertical swinging movement, is generally indicated at C; an upper boom section, pivotally mounted on the outer end of the lower boom section to swing in a vertical plane, is generally indicated at D; and a work platform, mounted on the outer end of the upper boom section, is generally indicated at E. The turret B is rotatable in either direction without limit, and the boom sections have the amplitude of swinging movement shown in FIG. 2. As shown in this view, the lower boom section C may swing through an arc of substantially 90 degrees, while the upper boom section D may swing through an arc of substantially 270 degrees. A hydraulic cylinder, indicated generally at F, is provided to swing the lower boom section, while a hydraulic cylinder, indicated generally at G, is provided to swing the upper boom section. Electric motor (see FIG. 8) and gearing means, indicated generally at H, is provided to rotate the turret on its swiveling axis.

Turning now to the details of the construction above the base portion A, the last-named portion, at the upper part thereof, is provided with a bed member 10 to support the turret B. The turret (FIG. 9) includes a sleeve part 11 rotatably and concentrically mounted through antifriction members on an inner upstanding tube part 12 fixed to the bed member 10. A ring gear 13, having internal teeth and of an internal diameter considerably in excess of the external diameter of the sleeve part 11, is arranged concentrically with respect to the sleeve part 11 and fixed to the upper surface of the bed member 10. Twin metal brackets 14 of elongated form are provided and bolted to the sleeve part 11 (FIG. 8), as at 15, the brackets having portions thereof extending laterally away from the sleeve part 11 in parallel and spaced-apart relation to one another, and being received in the end of a hollow arm 16 of generally rectangular cross section, the brackets being secured thereto, as by fasteners 17, for support of the arm from the sleeve part 11.

In the preferred form of the invention, the arm 16 is constructed of plastic material reinforced with glass fibers. The arm 16 extends outwardly and upwardly, as shown in FIG. 3. As shown in FIGS. 1 and 2, the arm-equipped turret is provided with a dome-like cover 18

which is removable and which is preferably constructed of the same material as the turret arm. Within the turret and mounted for rotation therewith are two electric-motor-and-pump units, indicated generally at 19, and supported from a bracket 20 also bolted to the sleeve part 11 of the turret by the bolts 15. One unit 19 operates the lower boom section C, and the other unit 19 operates the upper boom section D in a manner which will appear hereinafter. Electric-motor-and-gearing means H, which drives the turret, is also supported from the sleeve part 11. The last-named means, which is supported from a bracket 21 suspended from one of the brackets 14 and secured thereto as at 22, includes an electric motor 23 driving a pinion 24 through reduction gearing 25. The pinion 24 meshes with the teeth of the ring gear 13 to drive the turret, and it will be manifest from the foregoing that the sleeve part 11, the arm 16, the motor-and-pump units 19 and the electric-motor-and-gearing means H all rotate together as a unit.

At the other end thereof the arm 16 receives a transverse pivot shaft 26, mounting the inner end of the lower boom section C. The pivot shaft 26 extends through the inner end of the lower boom section, and this end of the last-mentioned boom section is arranged in side-by-side relation with the outer end of the arm 16 as indicated in FIGS. 3 and 4. The lower boom section, which is generally of tubular construction, is formed of plastic material reinforced with glass fibers and may be of generally rectangular cross section. The pivot shaft 26, best shown in FIG. 5, is stationary and supports the lower boom section through antifriction devices 27. An idler pulley 28 is rotatably mounted on the shaft 26 within the boom section C, as shown in the last-mentioned view, and also within the lower boom section and fixed to the shaft 26 in axially spaced relation is a radially projecting arm 29. At the other, or outer, end of the lower boom section C, a pivot shaft 30, mounting the upper boom section D, extends transversely into the last-named boom section from the same side of the boom section as the arm 16. The pivot shaft 30 is revoluble in the boom section C (FIG. 6) and equipped with suitable antifriction devices.

The pivot shaft 26 is mounted in an integrally formed cap portion 31 of the lower boom section, which has a somewhat thickened wall structure (FIG. 3) and is closed on the end, as at 32. As shown in FIG. 3, the cap portion as enlarged to extend below the tubular portion 33 of the boom section and in this region has an opening 34 facing the outer end of the boom section. The cap portion (FIG. 5) is internally reinforced, as at 35. The other end of the boom section C is provided with a similar cap portion 36 mounting the pivot shaft 30, as shown in FIG. 6. The cap portion 36 is provided with an internal web 37 supporting the inner end of the pivot shaft 30. The pivot shaft 30, which is hollow, has a flange 38 bolted to the inner end of the outer boom section D. Mounted on antifriction devices for rotation within the pivot shaft 30 is a hollow shaft 39, extending beyond the ends of the shaft 30 and having within the cap portion 36 and beyond the shaft 30 a radially extending arm 40 fixed to the shaft 39. Within the last-named cap portion a pulley 41 is fixed to the pivot shaft 30. The shaft 39 extends within the boom section D, which, like the boom section C, is of hollow construction, and within the boom section D the shaft 39 is provided with a split pulley 42 fixed thereto by a pin 43, the sections (FIG. 6) of the split pulley being adjustably bolted together, as at 44, to permit angular adjustment of one pulley section relatively to the other.

The upper boom section D is also constructed of plastic material reinforced with glass fibers and, as shown in FIG. 3, the boom section D is tapered to become progressively narrower in an outward direction, and at the outer extremity thereof is provided with an enlargement

45. The inner end portion of the outer boom section D is internally reinforced, as at 46, as shown in FIG. 6. The enlarged outer end 45 of the boom section D receives a laterally extending hollow pivot shaft 47 angularly rigid with the work platform E. As shown in FIG. 7, antifriction devices 48 are interposed between the shaft 47 and the boom section D. A pulley 49 is fixed to the shaft 47 within the boom section D. The work platform E, which is of bucket-like construction for a workman to stand in, has a substantially hollow lateral projection 50 mounting the shaft 47. The bucket-like work platform also has a frontal recess 51 for manually operated controls, controlling the boom structure and to be described hereinafter. The bucket-like work platform, together with the extension 50 and shaft 47, is formed of plastic material reinforced with glass fibers and, like the lower and upper boom sections, has a high dielectric strength to insulate a workman supported on the platform from electrical shock hazards, and also others, such as persons on or near the truck.

The hydraulic cylinder F, by which the lower boom is raised and lowered, has one end thereof (FIG. 3) pivoted to the turret arm 16, as at 52, at what may be termed the elbow of the arm 16, the pivot point being spaced below and somewhat to one side of the pivot shaft 26. The hydraulic cylinder has an extensible piston rod 53. A metal bracket 54, having a part extending through the wall structure of the tubular portion 33 of the lower boom section and fixed therein in a suitable manner, has a part projecting outwardly of and (FIG. 3) below the last-mentioned portion of the lower boom section and pivotally supporting the outer end of the piston rod 53, as at 55, a distance outwardly from the pivot 26, mounting the boom section C for vertical swinging movement. The arrangement of the last-mentioned hydraulic cylinder is such that when the piston rod 53 is extended the lower boom section C is raised, and when the piston rod is retracted, this boom section is lowered.

As best shown in the last-mentioned view, the hydraulic cylinder G, operating the upper boom section, is supported from the lower boom section intermediate the ends of the latter, the hydraulic cylinder G being fixed to the lower boom section below the latter by brackets 56. The hydraulic cylinder G has a piston 57 and piston rods 58, one at each side of the piston, to extend through the respective ends of the cylinder. One rod 58 is connected to one end of a cable 59, and the other rod 58 is connected to one end of a cable 60. The cable 60 is trained over the idler pulley 28 and has the other end portion thereof wrapped around the pulley 41 and secured thereto in a conventional manner. The cable 59 is trained over the pulley 41 and has the other end thereof wrapped around the last-named pulley and secured thereto in a conventional manner.

The arrangement is such that when the cable 59 is pulled by the corresponding piston rod 58 in a direction toward the inner end of the boom section, the upper boom section is swung upwardly through rotation of the pivot shaft 30. During this movement of the upper boom section D, the cable 59 is unlaid from the pulley 41 while the cable 60 is laid on the last-mentioned pulley. It will be understood that when the last-named piston rod is retracted to effect the last-named movement of the upper boom section, the other piston rod 58 is extended to permit the cable 60 to move over the idler pulley 28 in a direction to be laid on the pulley 41. It will be manifest from the foregoing that the upper boom section D is lowered through retraction of the piston rod 58 connected to the cable 60 and it will be understood that during this movement the cable 60 is unlaid from a pulley 41 while the cable 59 is laid on the last-mentioned pulley. The cable 60 extends into the boom section through the opening 34 in the cap 31 while the cable 59 extends into the cap 36 in like manner. A channel-shaped housing 36a fixed to the boom section C and disposed below the latter,

as shown in FIG. 3, extends a distance inwardly from the cap 36 to cover and insulate a portion of the cable 59 and a part of the piston rod 58 connected thereto.

A levelling mechanism is provided to maintain the bucket-like work platform E in upright position during all swinging movements of the lower and upper boom sections. To this end a rod 61 pivotally interconnects the outer end of the arm 29 fixed to the stationary pivot shaft 26 and the outer end of the arm 40 fixed to the revoluble shaft 39. The levelling mechanism includes the split pulley 42 from which cables 62 and 63 pass outwardly in the outer boom section D. One end portion of the cable 62 is wrapped around one section of the split pulley 42 and anchored thereto, and one end portion of the cable 63 is wrapped around the other pulley section and anchored thereto. The cables 62 and 63 are interconnected through rods 64 and cables 65, as shown in FIG. 3.

As shown in the last-mentioned view, the rods 64, which may be of substantial length and which are constructed of a material having a high dielectric strength, such as plastic reinforced with glass fibers, extend lengthwise in the upper boom section D. One rod 64 has the inner end thereof connected to the outer end of the cable 62, while the other rod 64 has the inner end thereof connected to the outer end of the cable 63. The other ends of the rods 64 are connected to the respective ends of the cable 65 which has the central or middle portion thereof wrapped around the pulley 49 and trained over an idler 66 supported in the outer end portion of the boom section D adjacent the enlargement 45. The cable 65 has the middle part of the portion thereof wrapped around the pulley 49 anchored to the latter, as at 66a, to resist slippage of the cable on the pulley under normal operating conditions.

The operation of the levelling mechanism will be manifest from the foregoing disclosure. When the lower boom section C is at rest, as in the position shown in FIG. 3, for example, and the upper boom section D is raised, the link 61, interconnecting the arms 29 and 40, tends to maintain the pulley 42 in stationary relation to the lower boom section C, and as the upper boom section D is raised from the position of FIG. 3, that is, swung in a clockwise direction as viewed here, the cable 62 is un-laid from the pulley 42, while the cable 63 is laid on the last-mentioned pulley, and through movement of the cables 62 and 63, which control the rods 64 and the cable 65, the bucket-like work platform is maintained in upright position. It will be understood that the cable 62 is laid and the cable 63 is un-laid when the upper boom section D is lowered. When the lower boom section C is raised, the pulley 42 is rotated in a clockwise direction, as viewed in FIG. 3, through the link-controlled arm 29. This movement of the pulley 42 relatively to the lower boom tends to maintain the bucket-like work platform in upright position, and it will be understood from the foregoing that when the lower boom section C is lowered, the pulley 42 is rotated relatively to the lower boom in opposite direction to maintain the platform in upright position. Should the cable 65 slip on the pulley 49, or should either of the cables 62 or 63 become slack, the sections of the split pulley 42 may be adjusted angularly to one another. This adjustment may be made to compensate for slippage of the cable 65 or to remove slack from the cables 62 and 63.

The base portion A of the boom structure is upwardly extensible to enable a workman on the work platform E to reach greater heights. To this end, the base portion A includes a parallelogram, best illustrated in FIGS. 13 and 14. The parallelogram is supported from the side frames 67 of the truck which mount, in fixed relation thereto, transversely extending metal members 68 of channel construction, the last-named members being supported from the side frames 67 through fittings 69. The channel members 68 are not centered on the truck frame,

but extend to one side, as shown in FIG. 14. A pair of arms 70 are provided at the last-mentioned side of the truck and extend upwardly from the respective channel members 68 in rigid relation thereto. One link of the parallelogram, which is of a plate-like construction and which is indicated at 71, extends between the arms 70 for pivotal support from the outer ends of the arms, this link being provided with pivots 72 mounting the link for vertical swinging movement on the arms 70. The companion link 73 of the parallelogram, which is of similar construction, extends between the channel members 68 in pivotal relation thereto, the link 73 being pivoted to the members 68, as at 74, inwardly toward the center line of the truck from the arms 70, as indicated in FIG. 14. As shown in FIG. 13, the pivot 74 may be constituted by a rod extending through the channel members 68.

The other ends of the links 71 and 73 are pivoted to an elbow fitting, indicated generally at 75, which, as viewed in FIG. 14, is generally of the shape of an isosceles triangle having two short sides. The plate-like links 71 and 73 are pivoted to one short side of the fitting 75 in spaced-apart relation by pivots 76 similar to the pivots 72. The elbow fitting 75 comprises two triangular side plates 77 laterally spaced apart by a wall 78 extending between the long sides of the triangles. The wall 78 and the side plates 77 are strengthened by a channel member 79 extending along the wall 78 between the plates 77 and provided with laterally spaced-apart lugs 80 for a purpose which will appear hereinafter. It will be understood from the foregoing that the links 71 and 73 extend between the side plates 77.

Links 81 and 82 of the parallelogram, corresponding to the links 71 and 73, respectively, each have one end pivoted to the other short side of the triangular fitting 75 by pivots 83 similar to the pivots 72, these ends of the links being spaced apart on the last-mentioned side of the fitting 75. The parallelogram includes a pair of channel members 84 spaced apart lengthwise of the truck and similar to the channel members 68, the members 84 supporting therebetween in fixed relation the bed member 10 of the turret B. A pair of arms 86, corresponding to the arms 70, project downwardly from the respective channel members 84 at the same side of the truck and the other end of the link 81 extends between the lower ends of the arms 86 and is pivoted to the last-mentioned ends by pivots 87 similar to the pivots 72. The other end of the link 82 extends between the channel members 84 above and inwardly toward the center line of the truck from the pivots 87, the last-named end of the link being pivoted to the channel members 84 by a pivot 88, similar to the pivot 74.

It will be manifest from the foregoing that regardless of the degree of extension of the parallelogram the links 71 and 73 remain parallel to one another and the links 81 and 82 remain parallel to one another, to thereby maintain the turret-supporting members 84 in parallel relation to the frame of the truck. The parallelogram constitutes an elevator for the turret B and is raised and lowered by hydraulic cylinders 89 and 90. For this purpose, the piston rod 91 of the hydraulic cylinder 89 may be pivoted on pivot 74 while the end of the cylinder may be pivoted between the lugs 80 of the fitting 75, as at 92. The hydraulic cylinder 90 may have the piston rod 93 thereof pivoted on pivot 88 while the end of the cylinder may be pivoted to the fitting 75, as at 94, between the lugs 80. As indicated in FIG. 13, the plate-like links of the parallelogram are suitably recessed to provide clearance for the swingable hydraulic cylinders 89 and 90. The arrangement is such that the parallelogram may be extended on extension of the piston rods 91 and 93 and folded on retraction of these rods. Furthermore, it will be manifest that the hydraulic cylinder 89 serves to swing the links 71 and 73 and the hydraulic cylinder 90 operates the links 81 and 82. It is important, as will appear hereinafter, that the hydraulic cylinders

89 and 90 may be operated independently of one another. For this purpose, an extensible control member, indicated generally at 95, is provided.

The extensible control member 95 in the illustrated form includes (FIGS. 13 and 14) tubular elements, 96, 97 and 98 in telescoping relation to one another, the element 98 telescoping into the element 97 and the latter telescoping into the element 96. Only the elements 97 and 98 are extensible. The control member 95 is vertically arranged and the upper end of the element 96 is pivoted for vertical swinging movement, as at 99, to an upstanding arm 100 rigidly supported on one of the channel members 84. A fitting 101 on the truck, the fitting being shown on one of the channel members 68, is connected to the element 98 and supports the latter for swinging movement with the elements 96 and 97. The fitting 101, which prevents axial movement of the element 98, provides a pivot which is of the fixed type. It will be manifest from the foregoing that the control member 95 is extended when the parallelogram or elevator moves from the lower broken-line position of FIG. 14 to the upper broken-line position of this view, and it will be understood that the control member 95 is telescoped when the parallelogram is folded.

The control member 95 carries adjacent the lower end thereof a mercury switch mechanism 102, the mercury bulbs of which, together with the electrical connections of which, are best indicated in FIG. 15. The function of the control member is to control, through tipping movement of the mercury switch mechanism 102, the operation of the hydraulic cylinders 89 and 90 to maintain the weight of the parallelogram between the wheels of the truck and thereby inhibit the tendency of this weight to tip the truck sideways. This is especially important when the truck is, itself, tipped to some extent due to the slope or unevenness of the ground, a very common operating condition. The switch mechanism 102 is supported for swinging movement on the lower end of the element 98. It will be understood from the foregoing that, if the piston rod 91 is extended and operated independently of or at a faster speed than the piston rod 93, the tendency is to move the turret bed to the left of the truck, that is, left as viewed in FIG. 14. If the piston rod 93 is extended and operated independently of or at a faster speed than the piston rod 91, there is a tendency to shift the turret bed to the right of the truck. The swingable mercury switch mechanism 102 controls these tendencies to inhibit tipping forces on the truck during the raising and lowering of the parallelogram and, furthermore, as will appear more fully hereinafter, the switch mechanism 102 effects shifting movement of the upper end of the parallelogram to the left or the right to compensate for unevenness or slope of the ground on which the truck is supported.

The parallelogram folds to be substantially centered on the truck body when in the stowed position illustrated in broken lines in FIG. 14. In order to achieve this, the lower pair of links of the parallelogram must have their lower pivotal connections to one side of the center line of the truck. Thus when the truck is level, as shown in FIG. 14, and the parallelogram is extended to its greatest height, shown in broken lines in the last-mentioned figure, the center of the turret bed must be to the right of the center line of the truck in order to effect a center of gravity between the wheels of the truck. As indicated in FIG. 15, the switch mechanism 102 carried by the swingable control member 95 includes two mercury bulbs, one indicated at 103 and the other at 104. The mercury bulb 103 controls the hydraulic cylinder 90 when and as the parallelogram is extended and controls the hydraulic cylinder 89 when and as the parallelogram is folded. The mercury bulb 104 controls the hydraulic cylinder 89 when and as the parallelogram is extended and controls the hydraulic cylinder 90 when and as the parallelogram is folded. These mercury bulbs control,

through the circuitry shown in FIG. 15, a pair of electrically operated valves 105, one valve 105 being interposed in each pair of fluid lines provided for the hydraulic cylinders 89, 90, the two-way hydraulic lines connected to the hydraulic cylinder 89 being indicated at 106 and the corresponding lines for the hydraulic cylinder 90 being indicated at 107. It will be understood from the foregoing disclosure that it is extremely advantageous to control the movements of the parallelogram so as to shift the center of gravity to the left or the right and thereby compensate for sideways tilt of the truck due to sloping or uneven ground. It will be manifest from the foregoing that the parallelogram or elevator may have many uses apart from its use to elevate turret-carried boom sections.

To enable the parallelogram to be completely folded for stowage on the truck under conditions where the truck is tipped sideways due to the slope of the roadway, for example, a switch 108 is mounted (FIG. 14), as on one of the side frames 67 of the truck, to be tipped by impingement with the parallelogram as the latter is folded, the switch 108 effecting the by-passing of the switch mechanism 102 as shown in FIG. 15.

As indicated in the last-mentioned view, a reversible electrically operated motor and pump 109 is provided to supply hydraulic fluid under pressure to the cylinders 89, 90 which operate the parallelogram. This motor and pump unit, similar to the motor and pump units 19 which are also reversible, is mounted (FIG. 2) for stationary support from the truck frame. As shown in FIG. 15 of the drawings, the hydraulic cylinder F, which operates the lower boom section C, is connected to one motor and pump unit 19 through two-way hydraulic lines 110, while the hydraulic cylinder G, which operates the upper boom section D is connected to the other motor and pump unit 19 through two-way hydraulic lines 111. The reversible motor 23, which drives the turret in either direction through previously described gearing, is also indicated in the last-mentioned view. The unit 109, like the units 19 and the reversible motor 23, may be operated either from the control unit 112 mounted in the frontal recess 51 of the bucket-like work platform or a control unit 113 mounted (FIG. 1) on the truck body. In the preferred form the control unit on the work platform is of the pneumatic type to further reduce electrical shock hazards to workmen, the last-mentioned control unit being connected to the pump motors and the motor 23 through flexible tubes 114 passing through the boom sections and formed of a dielectric material such as plastic. For this purpose eight tubes 114 are provided and eight air-transmitting mechanisms 115 of the manually operated type, constructed identically to the mechanism 115 shown in FIGS. 10 and 11, are connected within the bucket-like work platform to the respective upper ends of the tubes 114. The control mechanisms 115 are arranged in pairs so that the units 19, the motor 23 and the unit 109 may be operated in either direction. Eight air-receiving mechanisms 116, identical to the mechanism 116 shown in FIG. 12, are provided at the lower ends of the respective tubes 114.

The air-transmitting mechanisms 115 are supported from a common panel 117 through which each has a part extending for manipulation. Each transmitting mechanism 115 (FIG. 10) has a cup-like lower part 118 having, in the side wall structure thereof and near the bottom, an inlet and outlet 119, and having, in the center of the bottom, an air outlet 120. A vertically arranged bellows 121 is disposed in the bottom portion of the cup part 118 and has an upper end fitting 122 in fixed relation to the bellows and a lower end fitting 123 also secured to the bellows. The fitting 122 closes the upper end of the bellows except in the central region thereof and in this region the fitting 122 has an upwardly extending tubular part 124, providing an opening communicating with the interior of the bellows 120. The upper extremity

of the tubular part 124 is tapered, as at 125, and, as best shown in FIG. 11, this tapered portion is provided with a circumferential groove 126 seating an O-ring gasket 127 forming a valve seat.

The lower fitting 123 closes the lower end of the bellows except in the central region thereof and in this region is internally threaded to receive a nipple 128 on the corresponding air line 114, the nipple extending into the cup part 118 through the air outlet 120. The fitting 123 has in communication with the last-named threaded part a tubular part 129 extending upwardly in the bellows and opening into the latter. As shown in FIG. 10, the lower end of the bellows is rather narrowly confined between the tubular part 129 and the cup part 118. The upper end of the part 118 is filled by an insert 130 secured to the side wall structure of the part 118 as by screw 131. The insert 130, which has a central bore 132 therethrough enlarged at the lower end by a counterbore 113, has a peripheral shoulder 134 to abut the upper edge of the cup part 118. As shown in FIG. 11, the tubular part 124 of the upper bellows fitting may be extended with clearance into the counterbore 133.

Above the cup part 118, the insert 130 has a reduced externally threaded portion 135 threaded upwardly through the panel 117 for support by the latter, and the upper end of the portion 135 receives a nut 136 over a washer which bears against the top of the panel 117. A plunger 138, which extends loosely into the portion 132 so that air may pass lengthwise along the plunger, has an enlargement 139 at the lower end thereof to abut the bottom of the counterbore 133 and thereby prevent separation of the plunger from the insert 130 on upward movement of the plunger. As shown in FIG. 10, the enlargement 139 of the plunger is considerably smaller in diameter than the side wall of the counterbore 133. The plunger 138 normally extends a distance above the insert 130 and at the upper end thereof is provided with a disk 140 secured thereto and providing a button to move the plunger downwardly upon hand pressure of an operator thereagainst. A flexible cover 141, of the well-known accordion type, embraces the plunger 138. The cover has one end thereof suitably fixed to the upper part of the plunger below the disk 140 and has the other end disposed over the nut 136.

The enlargement 139 of the plunger has a conical recess 143 in the bottom thereof approximating the taper of the portion 125 of the tubular part 124, the last-named recessed part forming a valve for seating engagement with the valve seat 127. The upper end fitting 122 of the bellows 121 normally occupies the position shown in FIG. 11. Within the cover 141 a compression spring 141^a is provided, acting between the nut 136 and the disk 140, and embracing the plunger 138. The last-named spring, which may be omitted if the cover 141 is sufficiently resilient, normally maintains the plunger 138 in the position of FIG. 11. In this position, the plunger is spaced upwardly from the upper end fitting of the bellows 121 to permit air to enter or escape from this bellow and the corresponding air line 114. When the button 140 is depressed through hand pressure, the plunger 138 seats on the upper end fitting of the bellows, cutting off the entry of air to the bellows, and compresses the bellows to transmit, through the line 114, air under pressure to the corresponding air-receiving mechanism 116 such as that shown in FIG. 12.

Each air line 114 at the lower end thereof has a nipple 145 connecting the line to a fixed end (FIG. 12) of a bellows 146 forming a part of the corresponding air-receiving mechanism 116, the last-named end being fixed by a bracket 147. The nipple communicates with the interior of the bellows 146, and the other or movable end of the bellows 146 is closed by a fitting 148 including a plunger 149 extensible into the corresponding switch 150 (one switch 150 being provided for each air-receiving mechanism 116) to engage and move a spring-biased leaf

member 151. The leaf member 151 has a contact 152 and is biased in a direction toward a fixed contact 153 to normally engage the latter with the contact 152. The leaf member 151, with is a conductor and has a terminal 151^a, is provided with a contact 154 for cooperation with a fixed contact 155. When the bellows 146 is extended by air pressure from the air line 114, the plunger 149 is extended to engage and move the leaf member 151 in a direction to break the electrical connection between the contact 153 and the terminal 151^a and establish an electrical connection between the contact 155 and the terminal 151^a through the contact 154. It will be understood from the foregoing that when the button 140 is released by the operator, the bellows 121 is permitted to re-expand, moving the plunger 138 upwardly. This results in contraction of the bellows 146 which retracts the plunger 149, allowing the biased leaf member 151 to disengage the contact 155 and re-establish the electrical connection between the contact 153 and the terminal 151^a through the contact 152. It may be noted that, as shown in FIG. 12, within the casing of the switch 150 the plunger 149 is provided with an enlargement 149^a forming an abutment for engagement with the casing to prevent separation of the plunger from the switch casing.

In the diagram of FIG. 15, the air-transmitting mechanism 115 which controls raising of the lower boom section is indicated at 157, the control mechanism 115 for lowering this section at 158, the mechanism 115 for raising the upper boom section at 159, the mechanism 115 for lowering the upper section at 160, the mechanism 115 for raising the parallelogram at 161, the mechanism 115 for lowering the parallelogram at 162, the mechanism 115 for rotating the turret in one direction at 163, and the mechanism 115 for rotating the turret in the opposite direction at 164. As the operating connections between the control mechanisms 115 and the respective electrical motors are identical, only the connections of those controls 163 and 164 will be described.

When the operating plunger of the control mechanism 163 is depressed by the operator on the work platform, the contacts 152 and 153 of the corresponding switch 150 are separated to render the control mechanism 164 inoperative, and the contacts 154 and 155 are closed to complete a circuit from a source of power such as a generator (not shown) driven from the truck engine. This circuit includes a positive line 165 and a negative line 166. The closing of this circuit energizes a relay including an electromagnet 167 which closes contacts 168 and 169 to establish a current through line 170 to the turret motor 23. The motor is energized and rotated in one direction as the current passes through the motor and out line 171. When the operating plunger of the control mechanism 163 is released by the operator, the circuit through the motor is broken by separation of the contacts 154 and 155. The contacts 152 and 153 are then re-closed.

When the operating plunger of the control mechanism 164 is depressed by the operator, the contacts 152 and 153 of the corresponding switch 150 are separated to render the control mechanism 163 inoperative, and the contacts 154 and 155 are closed to complete the circuit through lines 165 and 166 to energize an electromagnet 172 which closes contacts 173 and 174 to establish a current through line 175 to the turret motor 23. The motor 23 is energized and rotated in the opposite direction as current passes through the motor and out line 171. When the operator releases the operating plunger of the control mechanism 164, the circuit through the motor 23 is opened through disengagement of the contact 154 with the contact 155. It will be understood from the foregoing that the control mechanisms 163 and 164 are of the dead-man type.

It has been previously indicated that when the parallelogram is raised, the electrically operated valve 105 controlling the cylinder 90 is controlled by the mercury bulb

103 and the electrically operated valve 105 controlling the cylinder 89 is controlled by the mercury bulb 104, and that the control of these valves by the bulbs is switched when the parallelogram is folded. This is accomplished in the manner set forth below.

When the operating plunger of the control mechanism 162 is depressed to lower or fold the parallelogram, a circuit 177 is established to energize an electromagnet 178. The magnet 178 breaks the line 179, as at 180, and establishes a line 181, as at 182, while breaking the line 183, as at 184, and establishing line 185, as at 186. This connects the mercury bulb 103 with the electrically operated valve 105 controlling the cylinder 89 and connects the mercury bulb 104 with the electrically operated valve 105 controlling the cylinder 90. Also as indicated in FIG. 15, the control unit 113 mounted on the truck body includes four manually operable switches 187, one switch 187 controlling each of the aforementioned electrical motors through either of the electro-magnets 167 and 172 associated therewith.

In the form of the boom structure shown in FIGS. 16 and 17 the turret, the lower boom section, the upper boom section and the bucket-like work platform are the same as those described above. The form of FIGS. 16 and 17, unlike the form of FIGS. 1 through 15, has the turret-carried boom sections thereof supported on a stationary base part, that is, the parallelogram or elevator is omitted. In the modified form the rotary turret is mounted on the suitably reinforced canopy 189 of the truck in axially fixed relation thereto. It will be manifest from the foregoing that the boom structure of FIGS. 16 and 17 is unable to reach the heights which may be reached with the first-described form of the boom structure.

As shown in FIGS. 16 and 17, the boom structure may be provided with a removable auxiliary boom, indicated generally at 190, which, while not limited thereto, is especially useful for raising and placing utility poles in upright position. The boom 190 comprises three pole members, two of the last-named members constituting a pair and each being indicated at 191, and the third pole member being of somewhat different construction and being indicated at 192. The pole members 191 and 192 are arranged in triangular relation as indicated in FIGS. 16 and 17 and in the position of the boom 190, shown in FIG. 16, extend upwardly and laterally. As indicated in the last-mentioned view, the pole members 191 are arranged in the same upward plane, the members 191 having their lower ends (FIG. 17) spaced apart and having their upper end portions in converging relationship. Each of the members 191 is constituted by at least two telescoping sections 193, 194 for relative lengthwise adjustment, the sections being releasably locked in their adjusted position, as by pins 195 passing through both sections. The pole member 192 is constructed of similar relatively telescoping sections 196 and 197 adjustably locked together in the same manner. The upper end of the pole member 192 extends between the upper ends of the pole members 191 and the three pole members are pivotally interconnected in this region, as by a pivot pin 198.

The lower ends of the pole sections 193 are apertured to be removably mounted on the threaded studs 199 extending therethrough substantially on the pivotal axis of the lower boom section C. Nuts 200 may be threaded on the respective studs by hand to removably secure these pole sections in place. As indicated in FIG. 17, one stud 199 extends laterally from the lower boom section C, while the other stud 199 extends in the opposite direction from the turret arm 16, the studs being supported from the pivot 26. A distance outwardly of the lower boom section from the pivotal axis of the last-mentioned section, a bracket 201 is secured to the side of the boom section C nearest the arm 16 and is provided with an aperture to removably receive a threaded stud 202 which extends transversely through the lower end of the pole section 197 and which may be removably secured to the bracket

201 by a nut 203 similar to the nuts 200, as indicated in FIG. 17. When the auxiliary boom 190 is secured in place as described above, the outer end of this boom may be projected laterally by upward swinging movement of the lower boom section from the position of FIG. 16, and it will be manifest from the foregoing that this end of the boom may be raised by lowering the last-mentioned boom section.

A lifting cable is indicated at 204. This cable is trained over a pulley 205 supported on the pivot pin 198 and is provided at its outer end with a cable fitting 206. The cable 204 runs downwardly along the pole member 192 and is trained over a pulley 207 suitably supported on the lower boom section C. The cable 204 passes downwardly from the pulley 207 through the central part of the turret and into the truck body where it is wound on a motor driven winch 208 of conventional design and equipped with conventional controls, not shown.

A pulley 209 (FIG. 16) within the truck body may cooperate with the cable 204 between the turret and the winch 208, and a fitting 210 is removably supported on the top of the turret to cooperate with the run of the cable between the pulleys 207 and 209 to prevent the cable from being rubbed on the turret. The fitting 210 is of upstanding tubular construction and at the upper end thereof is provided with pulleys 211 and 212 arranged in diametrically opposite relation to one another. When the lower boom section C is in the position shown in FIG. 16, the cable cooperates with the pulley 211. However, when the last-named boom section is raised from this position, the cable 204 leaves the pulley 211 and enters the pulley 212. The construction and arrangement provides a very satisfactory hoist which is one of the advantages of the boom structure.

It will be manifest from the foregoing disclosure that a further advantage common to both forms of the boom structure resides in the construction and arrangement of the boom sections and their support on the arm of the turret. In this connection it may be pointed out that when the lower boom section is projected across the turret from the arm 16, as shown in FIG. 16, and the upper boom section is raised, the tipping forces on the truck occasioned by the weight of the boom structure are materially reduced. It will be understood that the boom sections will not corrode due to their construction of reinforced plastic material and require little, if any, maintenance work. Furthermore, these boom sections have a very high dielectric strength to protect workmen from electrical shock hazards. Still further, in connection with electrical shock hazards, it will be noted that the upper boom section has no conductor for electrical current extending the length thereof. The boom sections and the turret arm do not have metal core members extending throughout their length to transmit shocks and the very length of the boom sections and the turret arm serve as additional electrical insulation from shock hazards. As previously indicated, pneumatic tubes 114 which run through the boom sections are formed of dielectric material, and the rods 64 within the upper boom section and which form a part of the levelling mechanism are also constructed of dielectric material. All lines to the work platform run within the boom sections throughout their lengths except where these lines pass through the hollow pivot shafts. The pneumatic lines which control the movements of the boom structure are of the self-charging type due to the construction and arrangement of elements in the air-transmitters 115. Due to the provision of the conically recessed valve seats 143 of these transmitters, condensation is prevented from dripping into the apertured upper end fittings 122 of the bellows 121 which form terminal connections of the air lines. The normally open air lines permit air to enter or leave them through the port 119 in each air transmitter which port also serves to permit the escape of moisture from within the transmitter. The normally open air lines permit air to escape as when

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the lines are subjected to heat, and permit air to enter the lines, as when the lines are subjected to cold temperatures.

Another feature of the boom structure resides in the simplification of the levelling mechanism for the work platform and the adjustability of this mechanism. An advantage of the canopy mounting of the boom structure, shown in FIGS. 16 and 17, resides in the mounting of the boom structure in such a way that the truck bed is left free for the stowage of accessory equipment, for example. A further advantage of the structure resides in the improved means for swinging the upper boom section on its pivotal axis through an arc of substantially 270 degrees. It will also be manifest that the use of the parallelogram or elevator, which may be mounted to fold lengthwise of the truck instead of transversely thereof, if desired, may add to the heights attained by the boom structure by many feet while maintaining tipping forces on the truck at a relatively low level or degree so that stabilizing outriggers are unnecessary on the truck.

Important advantages are obtained through the use of the boom actuating mechanisms and controls therefor illustrated and described above. In this connection it is notatable that the operating mechanism requires a minimum number of valves, owing to the use of reversible electric motors. Furthermore, motors are operated only during movements of the boom structure, and not continuously as in most hydraulic control mechanisms for boom structures of this general type. The use of electrical motors in mechanisms to move parts of the boom structure, such as the elevator, turret and boom sections, enables these parts to be moved smoothly without abrupt starts and stops. In this connection it may be noted that while the controls for the motor are of the single-speed type, the motors do not attain maximum speed at the commencement of their operation nor stop at maximum speed. This makes for smoother operation of the boom structure.

Still another feature of the boom structure is that it may be stowed easily on a truck within a relatively small space. In this connection it may be noted that the boom structure does not require the use of very long boom sections to reach substantial heights but employs an elevator for this purpose which may fold transversely of the truck and very compactly. The mounting of the lower boom section on the laterally projecting arm of the turret so that this section may be folded across the turret also facilitates stowage of the boom structure on a truck.

While only two forms of the boom structure have been illustrated and described above, it will be apparent to those versed in the art that the boom structure may take other forms and is susceptible of many changes in details without departure from the principles of the invention and the scope of the claims.

What I claim is:

1. In a mobile aerial tower, a truck, a support element, means mounting the support element on the truck to elevate and project it to either side of the truck, a turret rotatable on a substantially vertical axis on said support element, a boom pivoted to the turret for vertical swinging movement, a worker's platform supported from the outer end of said boom, means for operating said first-named means and for operating the turret and said boom, and means including gravity-responsive means interconnecting said support element and said truck to limit, on projection of said support element, the lateral extension of said support element and the degree of said projection within a predetermined limit of the height of elevation of said support element from the truck in accordance with substantially the center of gravity of the truck, tending to prevent tipping over of the truck.

2. In a mobile aerial tower, a truck, parallel linkages mounted on the truck, a support element, the support element and the truck being interconnected by said linkages, and said support element being projectable to either side of the truck and vertically, a turret rotatable on a sub-

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stantially vertical axis on said support element, a boom pivoted to the turret for vertical swinging movement, a worker's platform supported from the outer end of said boom, means for operating said boom and the turret and for operating said linkages, and means including gravity-responsive means, cooperating with said first-named means, operatively interconnecting the truck and said support element to limit the degree of projection of said support element from the truck in accordance with substantially the center of gravity of the truck, tending to prevent tipping over of the truck on projection of said support element through said linkages.

3. In a structure of the class described, a base member which may assume a tipped position, a plurality of pairs of links forming a parallelogram, the pairs being pivotally interconnected in end-to-end relation and the parallelogram being supported at one end from the base member for vertical and lateral extension therefrom, the other end of the parallelogram having a load-lifting and -shifting member thereon maintained in parallelism with the base member through said pairs of links, linkage-swinging means to swing adjacent pairs of the links in opposite directions and independently of one another to thereby raise and laterally relocate the position of the support member with reference to the base member, and self-operating control means acting on said linkage-swinging means to control the direction and extent of lateral relocation of the support member to thereby offset tipping forces on the base member as the parallelogram is extended, said control means including movable gravity-responsive control members and an element supported from the load-lifting and -shifting member, the last-named element being operative to move and reorient said gravity-responsive members in accordance with the shifting of the base member relatively to the load-lifting and -shifting member as the parallelogram is extended, said last-named element having a pivotal connection in fixed relation to the load-lifting and -shifting member and carrying the gravity-responsive members, and said element of the control means having a further swinging axis, which axis is in fixed relation to the base member, the last-named element being of a telescoping construction and being extensible on the extension of the parallelogram.

4. In a mobile boom structure, a truck having a canopy, a rotary turret mounted on top of the canopy and having a central passage therethrough communicating with an opening in the top of the canopy, the turret being mounted for swivelling movement on a vertical axis and having a load-supporting arm projecting upwardly and laterally therefrom, a load-lifting-and-supporting boom having the inner end thereof pivotally mounted on the outer end of said load-supporting arm for swinging movement of the boom in a vertical plane across the turret, means for effecting swinging movement of the boom, an auxiliary boom of tripod construction fixed to the inner end portion of the first-named boom and projecting outwardly therefrom substantially at right angles to the axis of the first boom for swinging movement therewith, the tripod having the foot of one leg secured to the first boom a distance outwardly from the pivotal connection of the latter to the arm, a flexible elongated hoist member running over the outer end of the auxiliary boom and running downwardly into the truck canopy through said passage in the turret, means to guide the run of said hoist member into the turret, and a winch within the truck canopy and on which the hoist member may be wound and unwound.

5. In a levelling mechanism for a work platform carried at the outer end of an articulated boom structure having two boom sections, the inner boom section being swingable through an arc of approximately 90 degrees and the outer boom section being swingable through an arc of approximately 270 degrees, a first pivot supporting the inner end of the inner boom section, a second hollow pivot angularly rigid with the inner end of the outer

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boom section and swingably mounting the outer section on the outer end of the inner section, a third pivot mounting the platform on the outer end of the outer boom section, the third pivot being fixed to the platform and having a pulley fixed thereon, a fourth pivot extending through the second pivot and being rotatable therein, the fourth pivot at one end of the second pivot having a pulley fixed thereto, a single link extending along the lower boom section and connecting at one end with the fourth pivot at the other end of the second pivot, the other end of the link having a fixed axis adjacent and parallel to the axis of the first pivot, and means interconnecting said pulleys and including cable portions, said link effecting angular adjustments of the platform on swinging movements of the lower boom section, and the last-named means effecting angular adjustments of the platform on swinging movements of the upper boom section.

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