

[54] SEQUENCED CRANE BOOM

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[21] Appl. No.: 134,243

Related U.S. Application Data

[62] Division of Ser. No. 780,993, Dec. 4, 1968, abandoned.

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[51] Int. Cl. B66c 23/06

[58] Field of Search 212/54, 55, 144; 52/115; 91/167-169; 92/51-53

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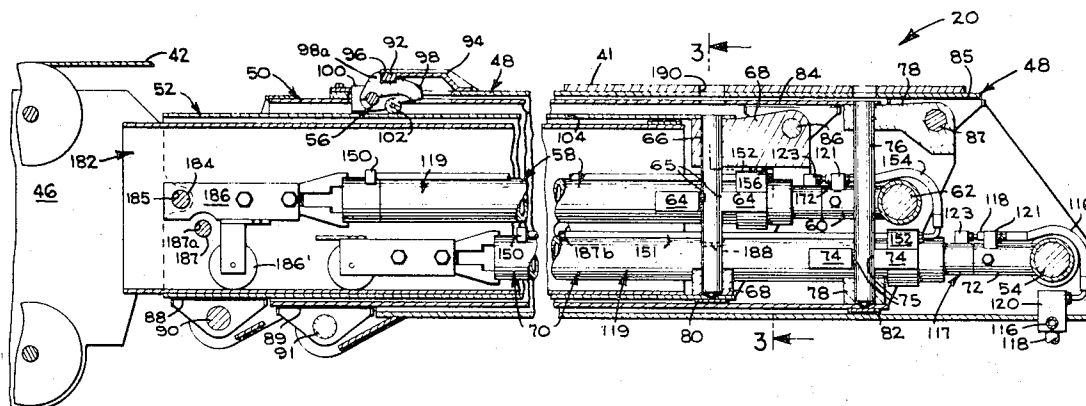
Primary Examiner—Harvey C. Hornsby

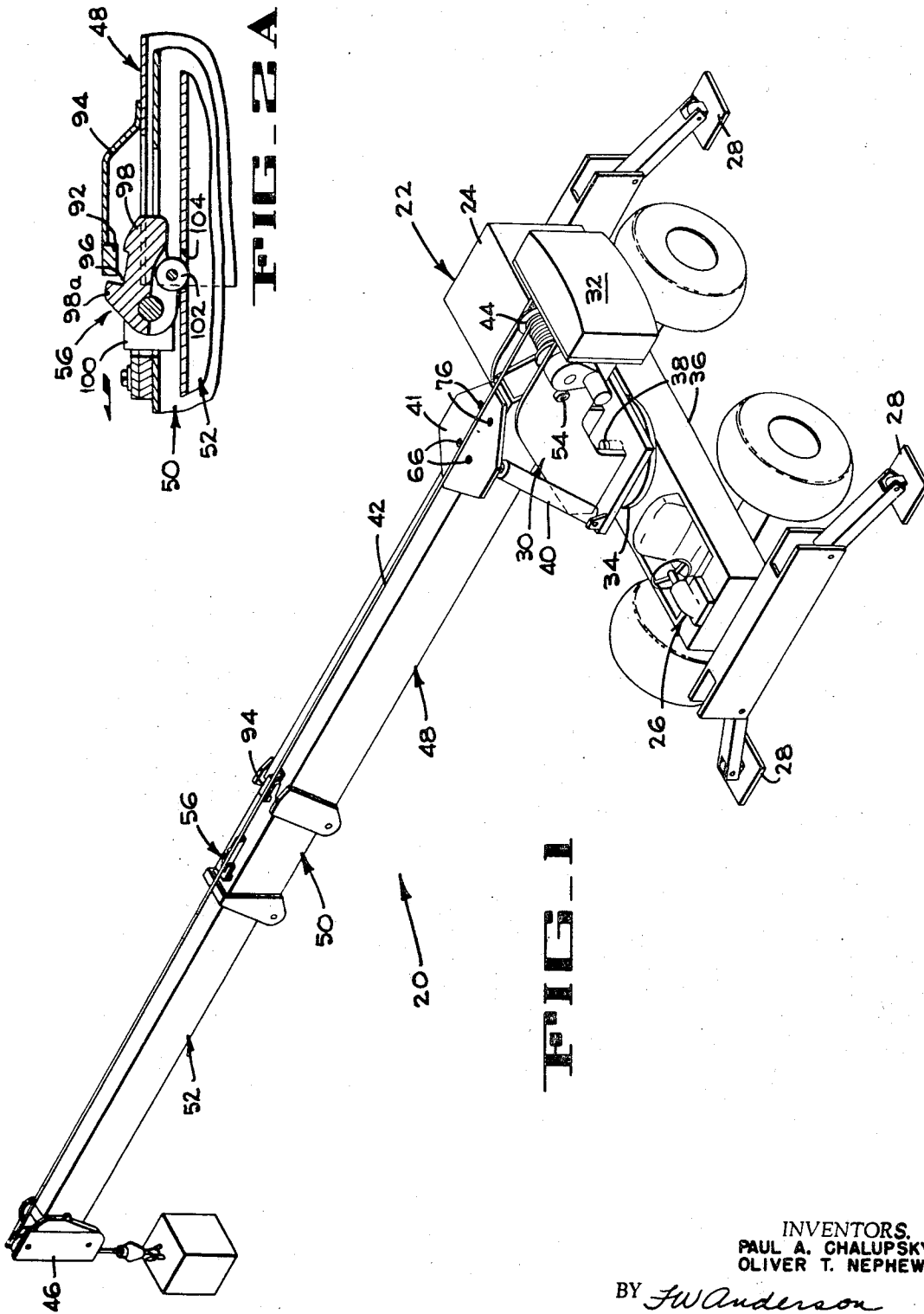
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[57] ABSTRACT

The invention concerns a hydraulically operated telescoping crane boom which is sequenced by means of a latch mechanism and sequencing valves such that the boom sections are automatically extended in order starting with the innermost section first. During retraction, the sequence is reversed; the outermost section being retracted first. Alternate forms are disclosed adding a manually operated section to the automatically operated boom and an entirely manually operated boom embodying the specific sequencing.

14 Claims, 26 Drawing Figures

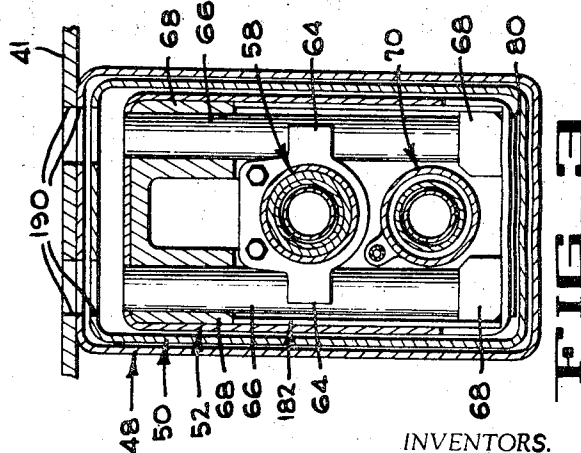
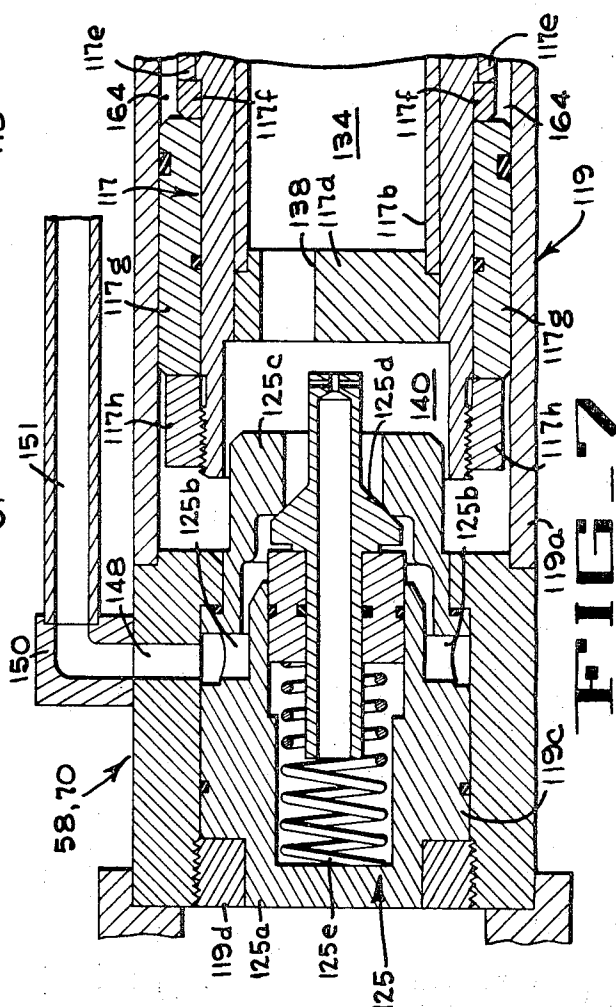
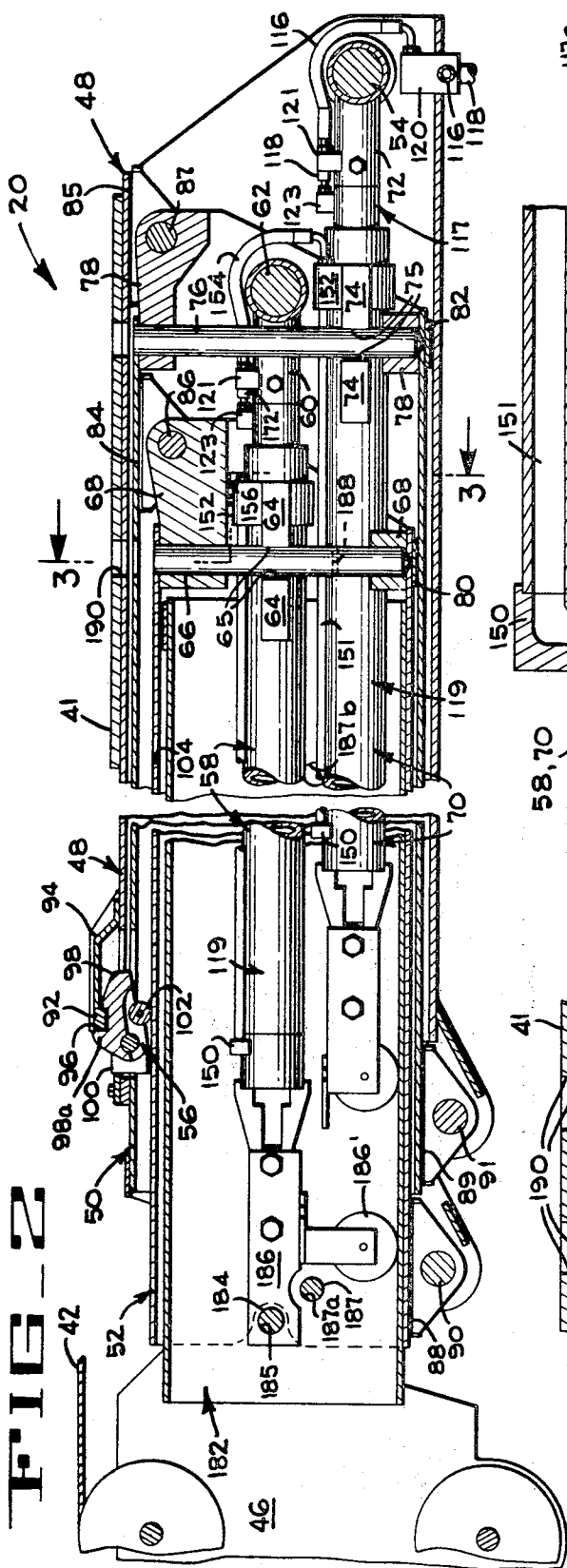




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FIG 8

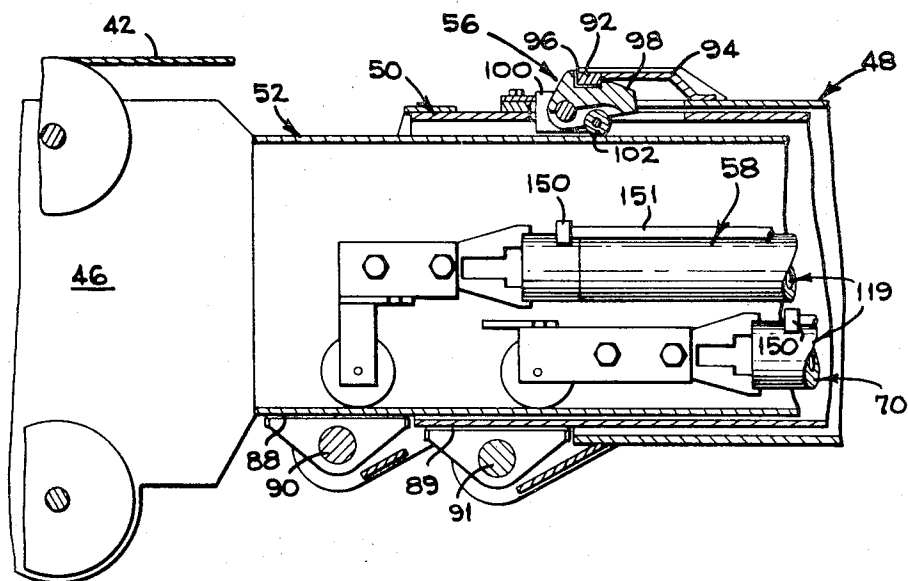


FIG 9

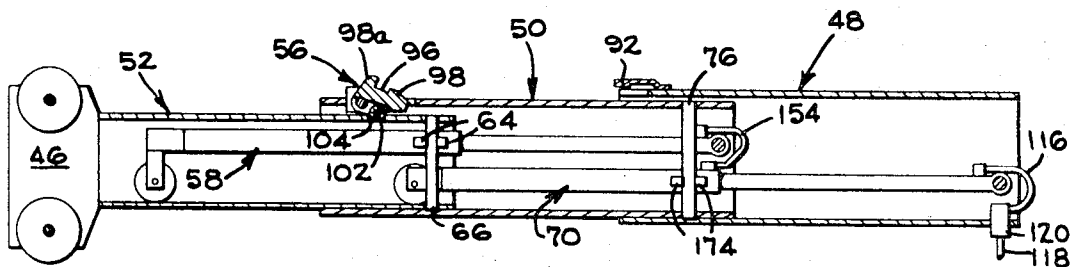
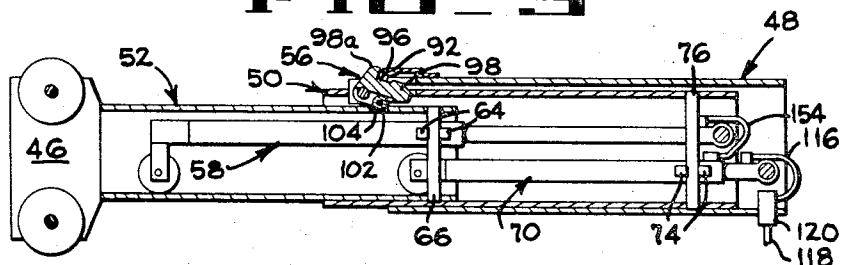


FIG 10

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FIG 11

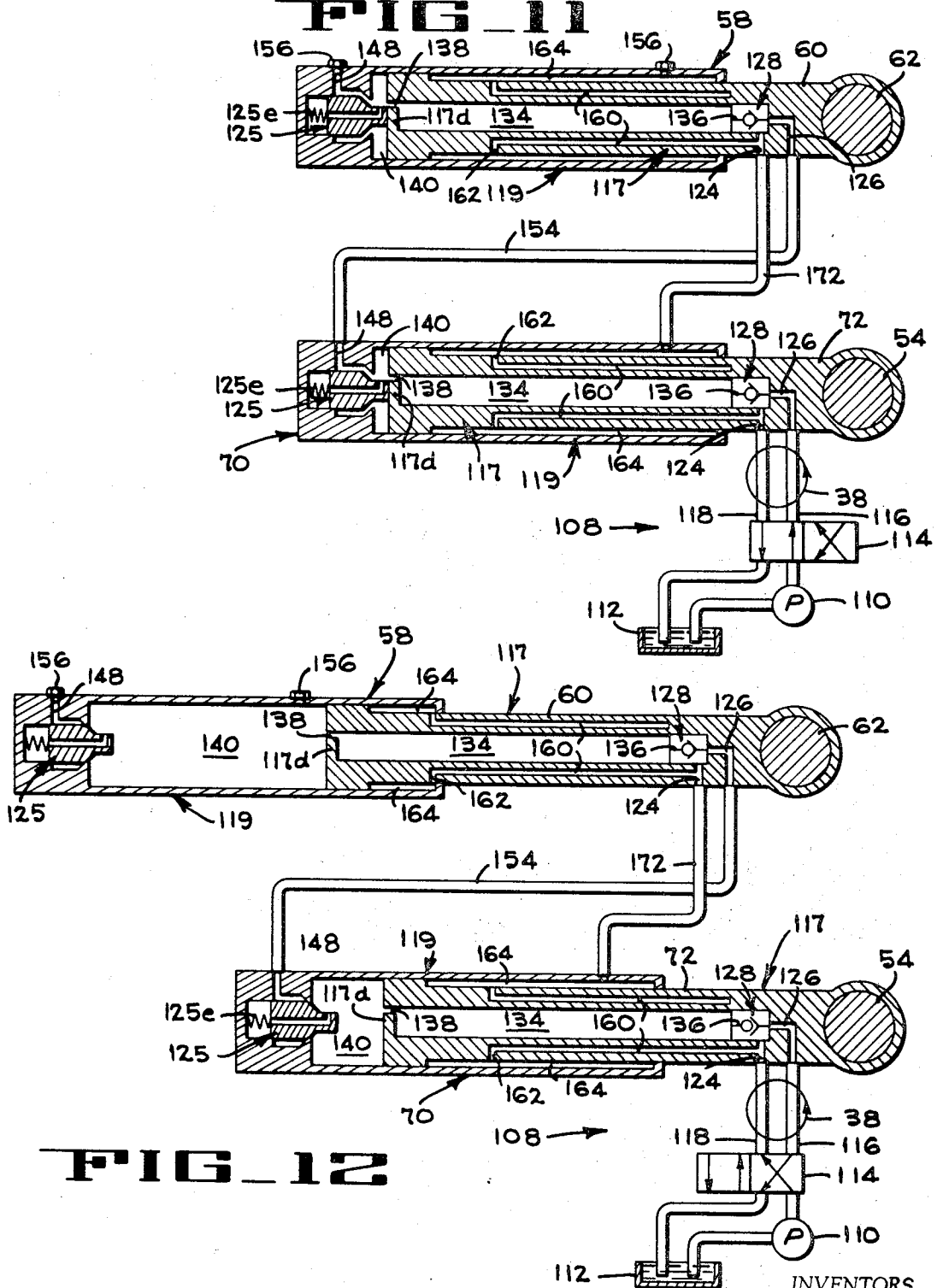


FIG 12

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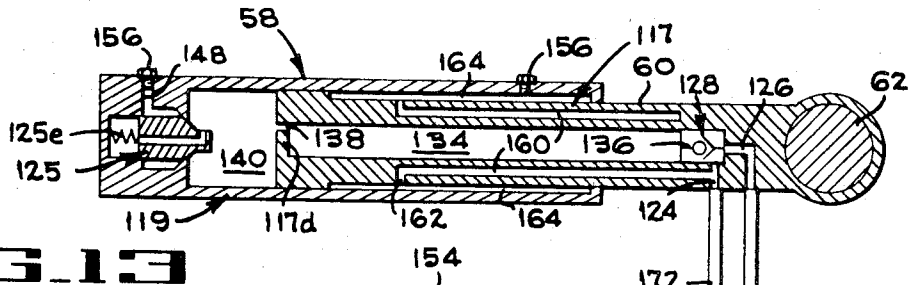


FIG. 13

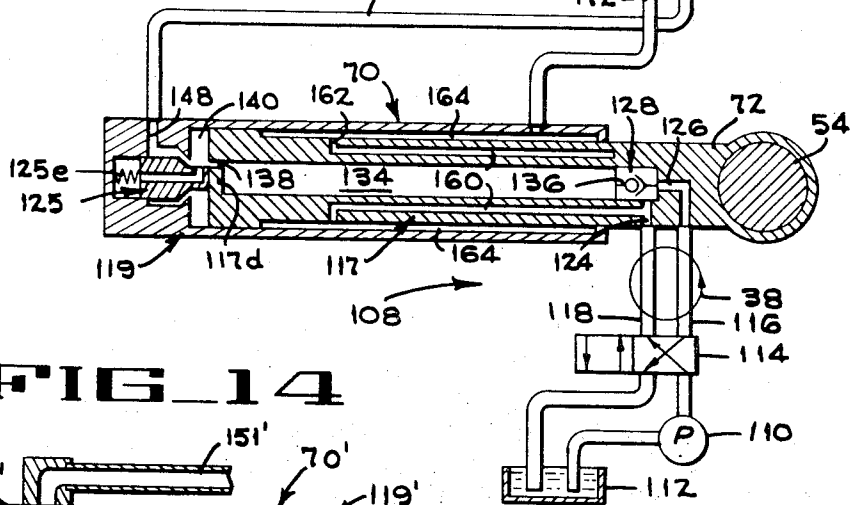


FIG. 14

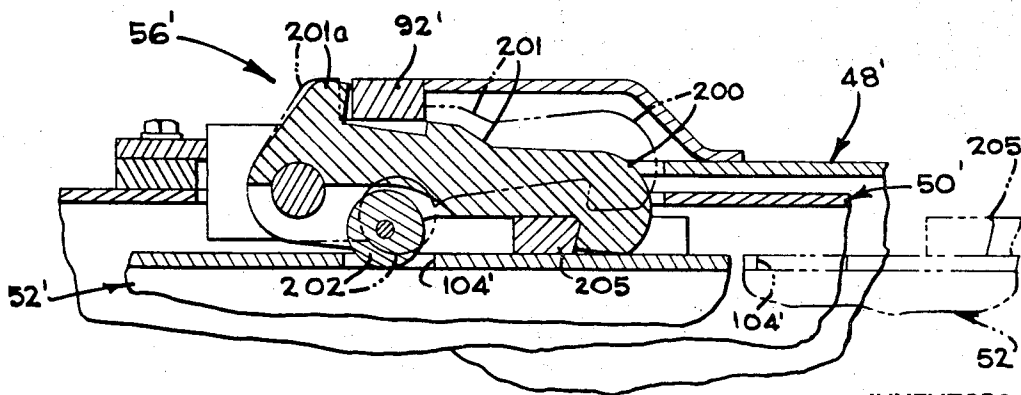
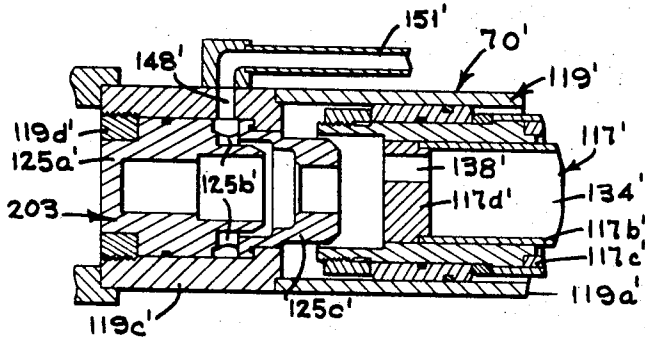


FIG. 15

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FIG 16

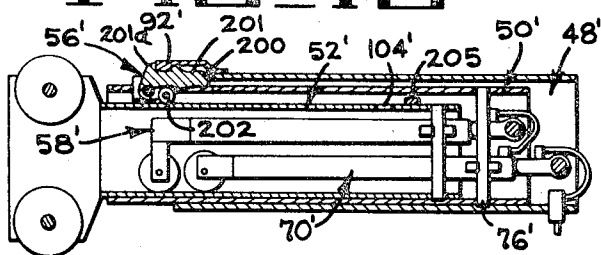


FIG 17

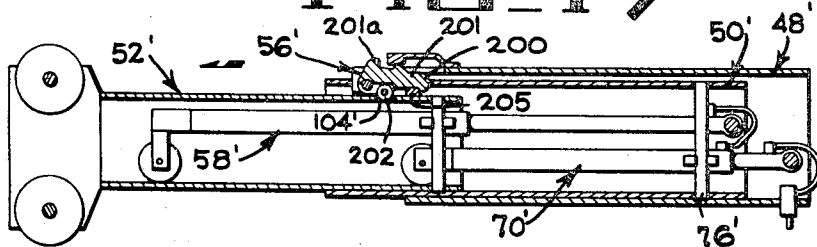


FIG 18

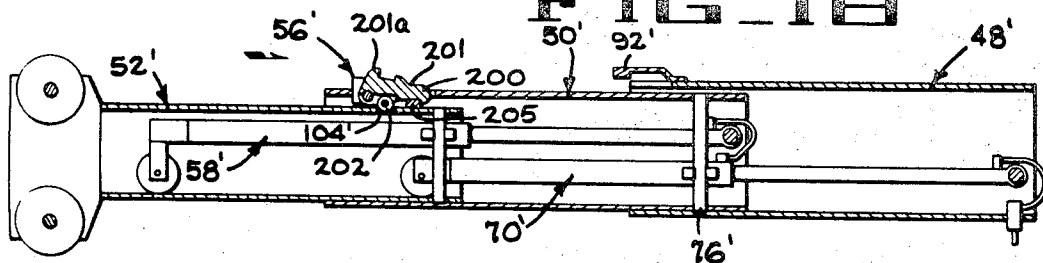
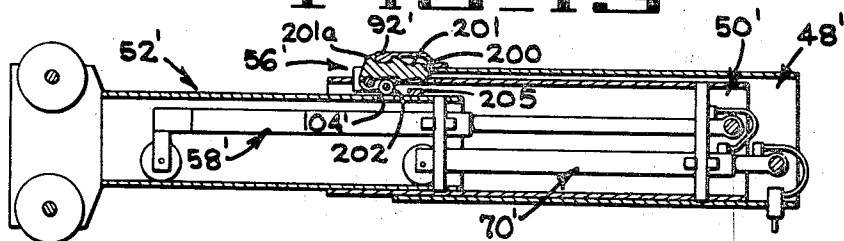


FIG 19



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FIG 20

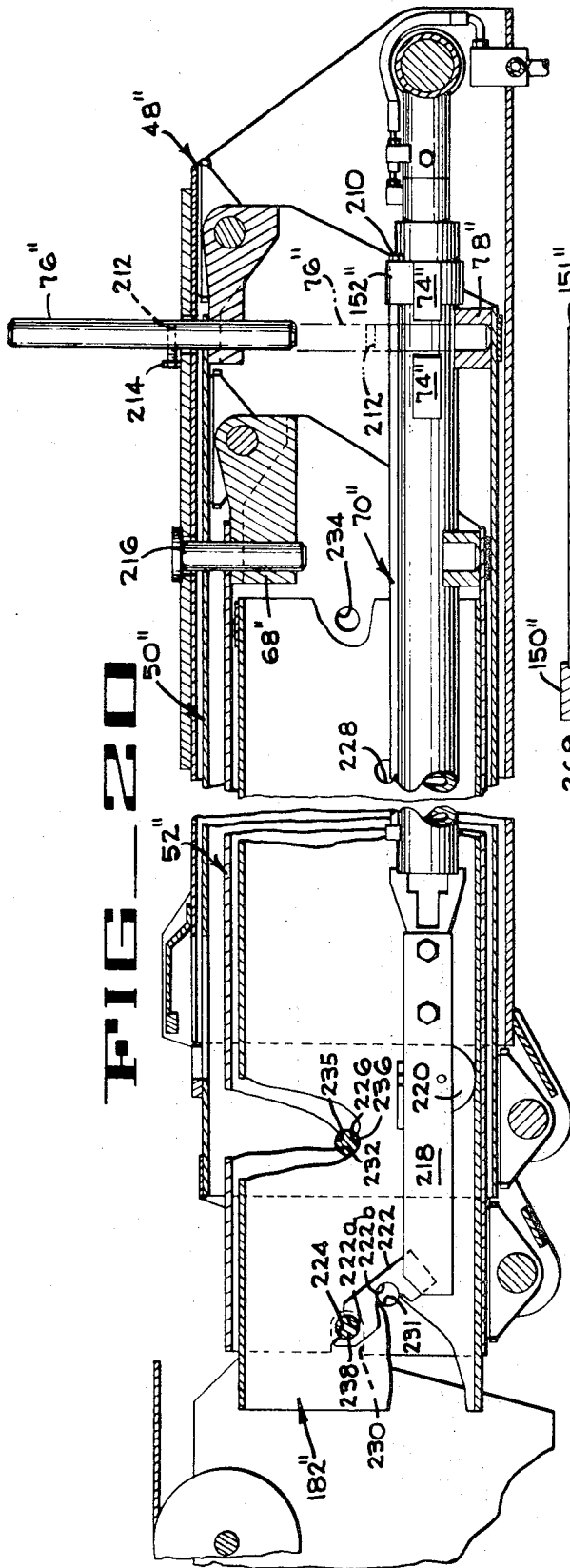
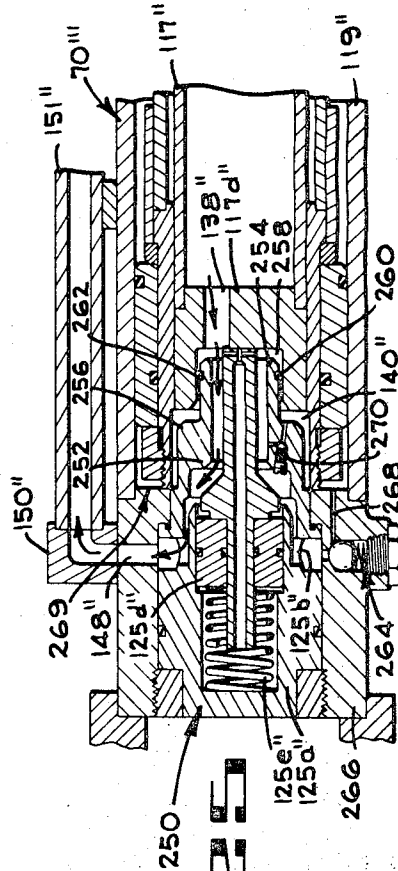


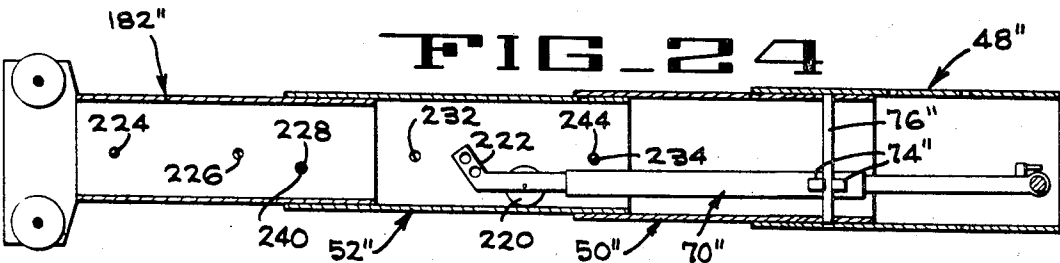
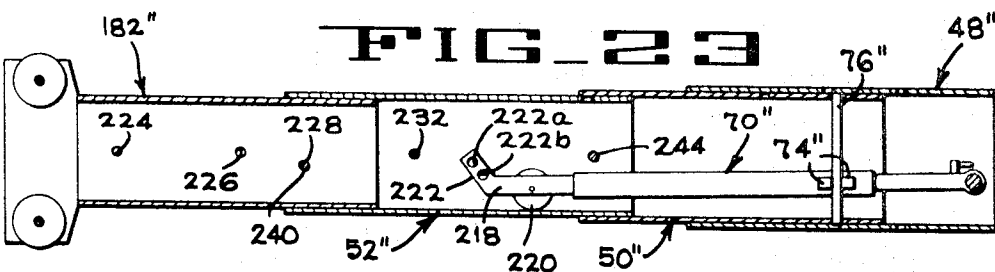
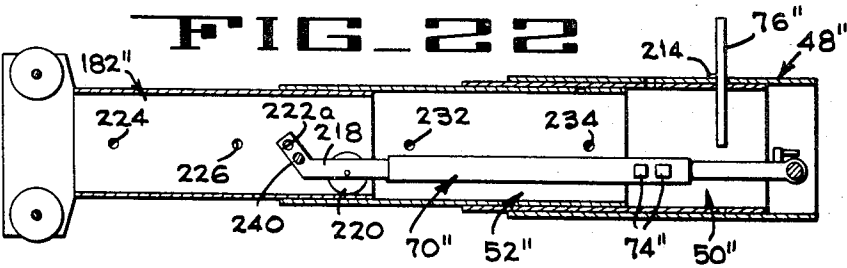
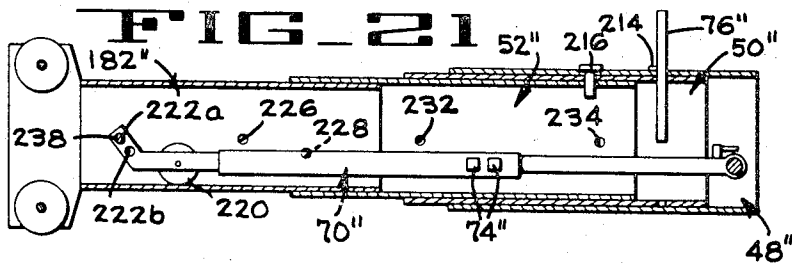
FIG 25



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SEQUENCED CRANE BOOM

This is a division of application Ser. No. 780,993 filed Dec. 4, 1968, now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to manual and automatically operated hydraulic telescoping crane booms such as employed on mobile transporters, and wreckers or in fixed installations.

DESCRIPTION OF THE PRIOR ART

One of the most important objectives in crane boom design is to reduce the weight of the extended boom to a minimum while retaining the required structural rigidity and strength in the boom for lifting. All components of the boom which are not structural increase the bending moment loads on the boom and transporter or mounting; and thereby decrease the lifting capacity of the crane in proportion to their weight and distance outward from the boom pivot or mount.

In presently employed cranes of the type having telescoping booms, the sequence in which the telescoping sections of the boom extend is generally determined by the relative friction between each of telescoping sections.

In practice, the innermost section usually extends first for a short distance until its overhang causes an increase in friction. The next innermost section then starts to extend. The extension of the telescoping sections therefore is progressive or entirely random in nature.

This characteristic is undesirable in that unnecessary structural and nonstructural weight is moved outwardly, substantially reducing the lifting capacity of the crane, except in the case where the boom is used in its fully extended position.

Another undesirable characteristic of presently employed telescoping booms is that the hydraulic cylinders which extend and retract the boom are base-end driven, requiring flexible hoses and reel mechanisms to prevent hose entanglement. The high pressure flexible hoses are heavier than tubing and the additional weight of the reel mechanisms further reduces the load lifting capacity of the crane.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a telescoping crane boom with an increased lifting capacity by reducing the non-structural extended weight of the boom. This object is achieved by an arrangement employing rod-end driven hydraulic cylinders, eliminating the requirement for flexible lines and reel mechanisms to prevent their entanglement.

Another object is to reduce the non-structural extended weight by eliminating the progressive or random extension of the telescoping sections by employing a predetermined sequence of extension and retraction.

A further object is to automatically control the extension sequence by a sequencing latch mechanism which releases the sections for extension in such a manner that the telescoping sections are permitted to extend consecutively beginning with the radially innermost unextended section.

Another object is to automatically control the retraction sequence by a hydraulic sequencing valve in cooperation with the rod-end driven cylinders which have pilot operated check valves. The telescoping sections

are retracted consecutively beginning with the radially outermost extended section. If the sequencing valves are not employed, the latching mechanism can be employed to control the retraction sequence.

Additional objects of sequencing valve are to act as bypass valve during the extension sequence and act as a safety valve, preventing collapse of the boom if a line interconnecting the hydraulic cylinders should fail.

Alternate forms of the invention are shown wherein boom sections can be hydraulically extended only by manually pinning and repinning boom sections to achieve sequenced extension and wherein the manual and automatic extension mechanisms are combined.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective of the sequenced crane boom of the present invention mounted on a transporter.

FIG. 2 is an enlarged fragmentary diagrammatic longitudinal cross-section of the boom of FIG. 1.

FIG. 2A is an enlarged view of a portion of FIG. 2 showing the latch in a different operating position.

FIG. 3 is an enlarged section of the boom taken on line 3—3 of FIG. 2.

FIG. 4 is a cross-section of a hydraulic cylinder that is mounted inside the boom, along the lower wall thereof.

FIG. 5 is an enlarged section of the rod end of the cylinder, showing the pilot valve, taken on line 5—5 of FIG. 4.

FIG. 6 is an enlarged section of the pilot valve, the view being taken on line 6—6 of FIG. 4.

FIG. 7 is an enlarged sectional view of the left end of FIG. 4 showing the sequencing valve of the hydraulic cylinder in the closed position.

FIG. 8 is a vertical section, similar to the left end of FIG. 2, but showing another embodiment of the crane wherein the head machine is connected directly to the boom section.

FIGS. 9 and 10 are schematic showings of the sequential extension of the boom sections in accordance with the present invention.

FIG. 11 is a schematic of the hydraulic system with both cylinders of the system in the retracted position.

FIG. 12 is a schematic, similar to FIG. 11, with the upper cylinder fully extended and the lower cylinder partially retracted.

FIG. 13 is a schematic, similar to FIG. 11, with the upper cylinder partially retracted and the lower cylinder fully retracted.

FIG. 14 is a fragmentary vertical section, similar to FIG. 7, but showing a modified embodiment of the hydraulic cylinder wherein the sequencing valve has been removed.

FIG. 15 is an enlarged view of a modified pawl and inner boom section.

FIGS. 16—19 are schematic views showing the sequential extensions of the boom sections in accordance with the modified hydraulic cylinder of FIG. 14.

FIG. 20 is an enlarged fragmentary longitudinal cross-section of an alternate form of the boom.

FIGS. 21—24 are schematic showings of the sequential extensions of the boom sections of the alternate form shown in FIG. 20.

FIG. 25 is a fragmentary longitudinal section, similar to FIG. 7, showing a further embodiment of the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

As seen in FIG. 1, hydraulically operated telescoping boom 20 is shown mounted on a mobile transporter 22. The transporter 22 is driven by an engine 24 that also provides power to the hydraulic system which operates the boom 20. Located adjacent to the normal controls associated with the transporter are controls 26 for the hydraulic system such as manually actuated levers. Adjustable outriggers 28 are located at the four corners of the transporter to provide a wider, more stable base for the crane when lifting large loads.

The boom 20 is mounted in a support 30 which includes a counterweight 32. The support 30 is rotatably mounted on a ring and traversing mechanism 34 which in turn is mounted on the frame 36 of the transporter. A hydraulic swivel 38 is employed to transmit hydraulic fluid from the stationary to the rotating portion of the crane. A pair of hydraulic elevating cylinders 40 (one only being shown) mounted between the support and a plate 41 secured to the boom are employed to lift the boom 20 to the desired elevation.

A cable 42 extends from an hydraulic winch 44 mounted in the support 30 to a head machine 46 on the end of the telescoping boom 20.

TELESCOPING BOOM

The telescoping boom 20, seen in FIGS. 1 and 2 is comprised of sections 48, 50 and 52. The outer section 48 which is not extendable, is pivotally mounted on pin 54 for rotation in a vertical plane by the elevating cylinders 40. The intermediate telescoping section 50 is mounted within the outer section 48. A sequencing latch mechanism 56, to be described later, interconnects the outer section 48 and intermediate section 50. Located within the intermediate section 50 is the inner telescoping section 52 on which the head machine 46 is mounted.

The internal arrangement of the telescoping boom sections is shown in FIG. 2. An upper hydraulic rod-end driven cylinder 58 is attached to the intermediate boom section 50 at its rod end 60 by a pin 62. Force transmitting lugs 64 (FIG. 3) on both sides of the cylinder 58 have inner opposing straight vertical faces 65 (FIG. 2) that exert the extension and retraction forces of the cylinder against a pair of vertical pins 66 that are mounted between bosses 68 of the inner boom section 52. Sufficient clearance is provided between the lugs 64 and pins 66 to permit tilting of the pins 66 in the vertical plane due to deflection of the boom under load without producing and induced bending movement in the cylinder. Therefore, as the hydraulic cylinder 58 extends, the inner boom section 52 is extended with respect to the intermediate boom section. As a result of the rearward lug position, the effective length of the cylinder subject to buckling and bending stresses is reduced by one-half permitting a lighter weight cylinder design.

The intermediate boom section 50 is extended by means of a similar, lower rod-end driven hydraulic cylinder 70. The cylinder 70 is attached to the fixed outer boom section at its rod end 72 by the boom mounting pin 54 which also attaches the boom to the support 30. Lugs 74 having inner opposing faces 75 on each side of the cylinder 70 transmit the forces developed by the cylinder to a pair of vertical pins 76. The pins 76 are mounted between bosses 78 of the intermediate boom section 50 in the manner described in connection with the pins 66 and bosses 68.

Lower wear strips 80 and 82 are located on the lower rear portions of the inner and intermediate boom sections, respectively, to reduce the sliding friction of the telescoping sections. Upper wear strips 84 and 85 are pivotally mounted on pins 86 and 87 respectively at the upper rear portions of the telescoping sections. Similar wear strips 88 and 89, pivoted on pins 90 and 91, respectively, are located at the lower forward end of sections 48 and 50. The pivoting action of the wear strips 84, 85, 88 and 89 prevents binding of the boom sections when they are under load.

SEQUENCING LATCH MECHANISM

The purpose of the sequencing latch 56 is to control the order in which the telescoping boom sections extend and retract. The latch mechanism, FIGS. 2 and 2A is comprised of a dog 92 that is attached to a steel finger 94 which is mounted on the outer boom section 48. The dog engages a notch 96 in the upper surface of a pawl 98 which has an upwardly projecting abutment 98a. The pawl is rotatably mounted between a pair of lugs 100 of the intermediate boom section 50. A roller 102 on the lower surface of the pawl 98 maintains the pawl in the raised position (FIG. 2) such that it engages the dog 92 as long as roller 102 is supported by the upper surface of the inner boom section. When the pawl 98 is in the raised position, the intermediate 50 and outer boom sections 48 are locked together by the pawl 98 and dog 92. Also, it will be noted that when these boom sections are locked together, the lower hydraulic cylinder 70 is held in the retracted position.

As will be explained more fully presently, during boom extension the inner boom 52 moves relative to the latched outer boom 50 and, as the inner boom section reaches its maximum extension, the roller 102 of the latch mechanism drops into a hole 104 in the top of the inner boom section 52. As the pawl drops into its lowered position, the dog 92 is disengaged from the notch 96 thereby unlocking the intermediate and outer boom sections as shown in FIG. 2A and permitting the intermediate boom to move away from the fixed outer boom 48.

The sequence is performed in reverse upon retraction such that the intermediate boom section 50 is retracted first and the inner section 52 thereafter.

HYDRAULIC SYSTEM

A hydraulic system 108 (FIG. 11) is employed to extend and retract the telescoping boom section. The system comprises a pump 110, a reservoir 112, a reversing valve 114 and the upper and lower boom actuating hydraulic cylinders 58 and 70, respectively. From the pump 110, reservoir 112 and controls 26, two hydraulic lines 116 and 118 lead to the hydraulic swivel 38 in the support 30. The hydraulic swivel 38 is of a common type having an inner fixed member containing multiple passages connected to the inlet lines. The multiple passages communicate with annular grooves in the outer rotating member. Each groove in turn has an outlet port to which the outlet hydraulic lines are attached. From the swivel 3 the lines 116 and 118 are routed and attached to an adapter block 120 (FIG. 2) mounted on the outer boom section. From the adapter block 120, the line 116 leads to a fitting 121 formed on the rod end of cylinder 58, and the line 118 leads to a fitting 123 that is formed on the rod end of the cylinder and provides a rod-retract port 124.

The hydraulic cylinders 70 and 58 are identical, and only the lower cylinder 70 will be described in detail. Each cylinder includes a fixed inner cylinder 117 and an outer cylinder 119 that telescopes over the inner cylinder 117. The inner cylinder includes a rod end wall 117a, spaced cylindrical members 117b and 117c, and a second end wall 117d all welded together to form a rigid unit. A plurality of annular spacers 117e, 117f, and 117g are secured on the unit by a locking ring 117h. The outer cylinder 119 includes an outer sleeve 119a that telescopes over the inner cylinder and is held in spaced relation to the cylinder by a nut 119b. An end member 119c is welded to sleeve 119a and receives a nut 119d which locks a valve assembly 125 in the end of the cylinder to form an end wall. The valve assembly comprises a body member 125a, and an annular spacer 125b, that has large passages through its periphery and bears against a valve seat 125c. A two-piece valve stem 125d is slidably disposed in the body 125a and is urged away from the end of the cylinder by a spring 125e. Suitable seal rings are disposed between the movable surfaces of the cylinder.

The hydraulic conduit 116 communicates with a port 122 in an upper extension of the rod end wall 117a of the cylinder. Fluid flows from port 122 downwardly through a passage 126 to a chamber 127 of a pilot check valve 128. The fluid flows around a stem 130 of the valve, unseats a spring-loaded ball 132 when fluid pressure is about 100 psi, and passes through a passage 136 into the central chamber of the cylinder. At the far end of the chamber the fluid passes through an opening 138 in wall 117d and enters a chamber that will be referred to as the "extend" cavity.

If the valve stem 125d of valve 125 is in the open position shown in FIG. 4, the fluid in the extend cavity can flow around the stem 125d, through the large passages formed in the annular spacer 125b and into a passage 148 in the member 119c. A fitting 150 receives a conduit 151 which extends along the cylinder to a connector 152 (FIG. 2) that is mounted on the cylinder. A conduit 154 is secured between the connector 152 of the lower cylinder 70 and the port 122 of the upper cylinder 58.

As mentioned the upper cylinder 58 is identical to the lower cylinder, however, the connector 152 on the casing of the upper cylinder is closed by a plug 156.

Referring to FIG. 4, it will be seen that the line 118 communicates through port 124 with a passage 158 that extends into an annular passage 160 from which ports 162 communicate with a retract chamber 164. A pilot channel 166 (FIG. 6) connects the annular passage 160 with the pilot valve 128. An exhaust port 168 (FIG. 4) connects the retract chamber 164 with a connector 171 that receives a conduit 172. The connector 171 is formed on the cylinder alongside the connector 152 and, in FIG. 2, the connector 171 is hidden by connector 152 and the conduit 172 is hidden by conduit 154. However, it will be understood that the conduit 172 extends from connector 171 to the rod retract port 124 in the fitting 123 of the upper cylinder 58.

In the embodiment of the crane illustrated in FIG. 2, the head machine is connected to boom section 52 by an auxiliary boom section in the form of a rectangular tube 182 that is welded to the head machine, is disposed inside boom section 52, and is connected thereto by a removable boom-locking pin 187 that extends transversely through aligned openings 187a in the sec-

tion 52 and in the tube 182. For a purpose that will be explained presently, a removable pin 184 is disposed in aligned openings 185 in an extension bar 186 of the case end of the cylinder 58 and in the tube 182. When the pin 184 is not in place, the case end of the hydraulic cylinder is supported by a roller 186' mounted on extension bar 186.

In another embodiment, the head machine is connected directly to the inner boom section 52, as by welding, as shown in FIG. 8 and the sequenced extension and retraction of the boom sections will be explained in connection with the FIG. 8 embodiment. It will of course be understood that both embodiments are identical except for the manner of connecting the head machine to the inner boom section.

OPERATION

The operation of the crane in elevating, rotating and hoisting is accomplished in a manner well known in the art. The extension and retraction of the telescoping boom sections is the subject of the present disclosure and will now be described with reference to FIGS. 8-12.

To effect extension of the boom 20, a control is actuated to dispose the reversing valve 114 in the position shown in FIG. 11, supplying pressure to line 116 from the pump 110. The hydraulic fluid flows into the chamber 134 of the lower hydraulic cylinder 70 through the pilot valve 128. The fluid then flows through the passage 138 into the extend cavity 140 of the cylinder 70.

At this time, the latch 56 (FIG. 8) has locked the intermediate boom section 50 to the non-extendable outer boom section 48 and the intermediate boom section 50, acting through the pins 76 (FIG. 9) and has locked the lower cylinder 70 in retracted position. The sequencing valve 125 (FIG. 11) of the lower cylinder 70 is held in the open position whenever the cylinder is in the fully retracted position due to the engagement of the stem 125d with the wall member 117d, and allows the fluid to flow to the upper cylinder 58 through line 154. The path of fluid flow in the upper cylinder 58 is identical to that of the lower cylinder 70; however, the extend cavity 140 of the upper cylinder is closed by the plug 156, and therefore the upper cylinder 58 extends, extending the inner telescoping section 52 of the boom 20 through the engagement of the lugs 64 on the cylinder casing with the pins 66 as shown schematically in FIG. 9.

The lower cylinder 70 is prevented from extending until the inner telescoping section has been fully extended and has actuated the latch mechanism to release the lower hydraulic cylinder 70. When cylinder 70 is released, it is extended and it extends the intermediate boom section 50 through the engagement of the lugs 74 with the pins 76 as seen in FIG. 9. After the lower cylinder 70 has extended approximately one-half inch, the sequencing valve 125 is closed by spring 125e preventing the collapse of the cylinder 70 if the line 154 between the upper and lower cylinders should fail. No flexible lines are required between the cylinders since there is no motion between the case end of the lower cylinder and the rod end of the upper cylinder.

During retraction, it is desired that the intermediate boom section 50 retracts before the inner section 52. When the reversing valve 114 is moved to the position shown in FIG. 12, fluid under pressure enters line 118, passes through the hydraulic swivel 38 and enters the

annular passage 160. The fluid then enters the retract cavity 164 of the lower cylinder 70. The retract cavity of the upper cylinder 58 is similarly pressurized by fluid from line 172 which exits from the lower retract cavity 164 through port 168. Simultaneously, both pilot channels 166 are pressurized and the pilot valves 128 of both cylinders are opened when the retract pressure has reached approximately 100 psi. Upon opening of the pilot valves 128, the fluid in both extend chambers would ordinarily be allowed to escape from the cylinders; however, the fluid of the upper cylinder 58 which is exhausted through line 154 is blocked by the closed sequencing valve 125 of the lower cylinder 70 as seen in FIG. 12. The blocking action of the sequencing valve prevents retraction of the upper cylinder 58 and the inner boom section 52 which is controlled thereby until the lower hydraulic cylinder 70 has completely retracted the intermediate boom section 50 (FIG. 13).

The retraction of the lower cylinder 70 opens the sequencing valve 125, unblocking the conduit 154 and allowing the upper cylinder 58 to retract in response to pressure in the retract chamber 164. As the intermediate boom section approaches its retracted position, the abutment 98a of the pawl engages the dog 92, causing the pawl to rotate counterclockwise into locked engagement with the dog.

The embodiment shown in FIG. 2 which features a particular manner of connecting the head machine 46 to the inner boom 52 is used when an additional boom length is desired. In general this is accomplished by disconnecting the auxiliary boom section 182 from the inner boom section 52; locking all three boom sections 52, 50 and 48 together so they cannot be extended; disconnecting the upper power cylinder 58 from the inner boom section and connecting it to the auxiliary boom section 182; energizing the cylinder to hydraulically jack the auxiliary section to an extend position; reconnecting the auxiliary section to the inner boom section; disconnecting the cylinder from the auxiliary boom section and reconnecting it to the inner boom section; and unlocking the boom sections 48, 50 and 52 from each other. When the boom sections are sequentially actuated as previously explained, the boom will have the added reach provided by the extended auxiliary boom section 182.

The locking of the boom sections 48, 50 and 52 to each other is accomplished by raising the two pins 66 upwardly through holes 190 in the plate 41 secured to the outer boom section until transverse threaded holes 188 in the pins 66 are disposed above the plate. Capscrews (not shown) are then threaded into the holes 188 to lock the pins in this elevated position in which their lower end portions are out of engagement with the lugs 64 of the upper cylinder. Since the pins 66 are engaged in aligned holes in the three boom sections 48, 50 and 52, they are locked against forward movement.

The pin 187, which is securing the inner section 52 to the auxiliary boom section, is then withdrawn from the aligned holes in the booms to permit movement of the auxiliary section.

The cylinder 70 is then energized by directing pressurized fluid through conduit 116 into the hydraulic system.

When the auxiliary boom section is extended to a position where an aperture 187b near its trailing end portion is aligned with the two apertures 187a in the inner boom section 52, the power cylinder is de-energized

and the pin 187 is inserted through the two apertures 187a and the aperture 187b to connect the auxiliary boom section 182 in its extended position to the inner boom section.

The pin 184 is withdrawn from the forward extension of the power cylinder and the power cylinder is retracted to a position wherein the pins 66 can be lowered to a position between the lugs 64.

The sequential actuation of the boom sections as explained in connection with the FIG. 8 embodiment is then carried out.

In a further embodiment of the invention, the structure is substantially identical to the structure of either of the embodiments illustrated in FIG. 2 or FIG. 8, and in the illustrations of FIGS. 14-19, parts that correspond to identical parts of FIGS. 2 or 8 will be given the same reference numerals followed by a prime mark. The embodiment of FIGS. 14-19 differs in three areas: (1) the pawl of the latch mechanism is provided with a hooked end 200 as shown on the pawl 201 of FIG. 15, (2) the valve assembly at the case end of each power cylinder has no valve stem, as shown by the valve assembly 203 of FIG. 14 in the power cylinder 70', and (3) a bar 205 (FIG. 15) is welded on the upper surface of the inner boom section. With this arrangement the advantageous sequencing of the boom sections can be accomplished without using a sequencing valve since the engagement of the hooked end 200 of the latch pawl with the bar 205, will, in a manner to be described presently, prevent retracting movement of the inner boom section 52' until the intermediate section 50' has been retracted.

Referring to FIG. 16 the unextended position of the boom sections 48', 50' and 52' is illustrated. When the control lever is actuated to direct pressurized fluid into the hydraulic system through the ports adapted to cause extension of the upper cylinder 58' and the lower cylinder 70', the upper cylinder 58' will be extended while the lower cylinder will not extend due to its locked connection with boom section 48' through pins 76' and latch mechanism 56'. When the inner boom reaches its extended position, the roller 202 of the latch mechanism drops into the hole 104' in the boom section 52', permitting the pawl 201 to drop downwardly out of latched engagement with the dog 92'. The intermediate boom section 50' is now free to be extended. As the section 50' starts to move, the hooked end 200 of the pawl drops behind the bar 205 on the boom section 52'. The boom sections 52' and 50' then move outwardly together. When the lower cylinder 70' has been fully extended, the boom is in fully extended position.

When the boom is to be retracted, the control lever is actuated to direct pressurized fluid to the cylinders 58' and 70' in a direction to cause retraction of the boom sections. Since the valves 203 in the case ends of cylinders 58' and 70' do not have valve seating members, the pressurized fluid that has caused extension of the boom sections can be forced back to the sump when pressurized fluid is applied to the opposite ends of the cylinders. Accordingly, when pressure is applied to the case ends of the cylinders, they both try to retract. However, the hooked engagement of pawl end 200 and the bar 205 on the inner section as shown in FIG. 18 prevents the inner boom section 52' from retracting relative to the boom section 50'. Since the cylinder 58' cannot retract, the cylinder 70' does retract

and thereby retracts the intermediate boom section 50'.

As the latch mechanism 56' reaches the fixed dog 92', the upper end 201a of the pawl 201 engages the dog, causing the pawl to pivot counterclockwise (FIG. 15) and move away from the bar 205. The inner boom section is thus freed, and the power cylinder 58' retracts and moves the inner boom section to retracted position.

Another embodiment of the present invention is illustrated in FIG. 20. In this arrangement the boom sections are similar to those in FIG. 2 and, in describing this embodiment, parts that correspond to identical parts of FIG. 2 will be given identical reference numerals followed by a double prime mark.

In general the mechanism includes a fixed outer boom section 48'', an intermediate boom section 50'', an inner boom section 52'', and an auxiliary boom section 182''. A power cylinder 70'' that is identical to cylinder 70 with the exception that connection 152'' is capped by a plug 210 rather than being in communication with a second cylinder.

A pin 76'' is adapted to establish a driving connection with lugs 74'' of the cylinder 70'' and is further provided with a threaded transverse hole 212 which is adapted to receive a threaded pin 214 when the pin 76'' is raised to the full line position of FIG. 20. When the pin 214 is inserted in the hole 212, the pin 76'' is held in elevated position, out of engagement with the cylinder 70'' but locking the outer boom section 48'' to the intermediate boom section 50''.

A pin 216 is removably positioned in aligned holes in the boom sections 48'', 50'', and in the upper boss 68'' of the inner boom section 52'' to lock all three boom sections against relative longitudinal movement.

The cylinder 70'' is provided with an extension 218 that is supported by a roller 220. The extension 218 is provided with an inclined arm 222 that is welded to extension 218 and is provided with two spaced holes 222a and 222b.

The auxiliary boom section 182'' has a pair of aligned holes 224 (one only being shown) near its forward end, a pair of aligned holes 226 (one only being shown) spaced rearwardly of the holes 224, and a pair of aligned holes 228 near the rear end of the section. The inner boom section 52'' has a pair of transversely aligned recesses 230 on its forward edge, two pairs of aligned holes 231 and 232 rearwardly of the forward edge, and a pair of aligned holes 234 near its rearward end (one hole of each pair being shown). The intermediate boom section 50'' has a pair of aligned holes 235 (one only being shown) near its forward end. A pin 236 is normally positioned in the six aligned holes 226, 232 and 235 to lock the sections together.

The boom is extended in the following manner. With the elements in the position shown in FIG. 20, the pin 236 is first removed, and a pin 238 is positioned in the hole 222a of the cylinder extension 222 and in the two aligned holes 224 of the auxiliary boom section 182'' as shown in FIG. 21. Pressurized fluid is then directed into the power cylinder 70'' in a direction to cause the cylinder to extend and move the auxiliary boom section to the position of FIG. 21 wherein holes 228 in boom section 182'' are aligned with holes 231 in boom section 52''. The pin 238 is removed, and the cylinder 70'' retracted until the hole 222b becomes aligned with the four aligned holes 228 and 231. A pin 240 is placed in

the five aligned holes as seen in FIG. 22 and vertical pin 216 is removed from its locking engagement with the boom sections. Then, when the cylinder 70'' is extended, the inner boom section 52'' and the auxiliary boom section 182'' are moved to the position of FIG. 23, bringing the aligned holes 234 of section 52'' into alignment with the holes 235 in boom section 48''. The pin 240 is removed, the power cylinder 70'' is retracted, and the pin 240 is replaced in the four aligned holes 228 and 231 to lock sections 182'' and 52'' together during subsequent extensions of the other sections.

The vertical pins 76'' are now lowered to a position between the lugs 74'' of the cylinder 70'' and, in this lowered position, they are free of the outer boom section 48''. A pin 244 is placed in the four aligned holes 234 and 235. The power cylinder 70'' is again extended and, through the pin 76, it drives the intermediate boom section 50'' outwardly. Section 50'', in turn, drives the inner section 52'' outwardly through the pin 244. The boom is now in fully extended position.

To retract the boom, the sequence is reversed. The power cylinder 70'' is retracted, to pull the intermediate section 50'' inward. The pin 244 is removed and the vertical pins 76'' are raised to the full line position of FIG. 20. The pin 240 is removed from the four aligned holes 228 and 231, the cylinder 70'' is extended and the hole 222b of the cylinder is brought into alignment with these four holes, and the pin is placed in the five aligned holes. The cylinder is retracted, to draw the inner cylinder 52'' inwardly. The pin 240 is once more removed, the cylinder is extended to bring the hole 222a into alignment with the two aligned holes 224 of the auxiliary boom section 182'', the pin 238 is inserted in the three aligned holes, and the cylinder is retracted to move the auxiliary section back to the position of FIG. 21.

Another embodiment of the invention incorporates a dual action sequencing valve assembly 250 seen in FIG. 25, which is a modification of the sequencing valve 125 employed in the hydraulic cylinder 70 of the original embodiment shown in FIG. 7. The modifications incorporated in the valve 250 perform the functions of both the valve 125 and latch mechanism 56.

The valve assembly 250 mounted in the end of a hydraulic cylinder 70''' comprises a body member 125a'' and an annular spacer 125b'' that has a large passage through its periphery and bears against a valve seat 252. The valve seat 252 has an extension 254, of a smaller diameter than the body of the seat at 256 which extends into a cavity 258 formed in an end wall 117d'' of a cylinder rod 117''.

In order to isolate the cavity 258 from the extend cavity 140'', a seal ring 260 is installed in an annular groove 262 in extension 254. A two piece valve stem 125d'' is slidably disposed in the body 125a'' and is urged toward the valve seat 252 by a spring 125e''. In addition, seal rings are located between the movable and stationary surfaces of the valve and cylinder.

A check valve 264, which releases at approximately 2,000 psi, is located in the end member 266 of the cylinder and is effective to permit flow between the port in spacer 125b'' and the extend cavity 140'' through passage 268 and clearance space at 269 between the end of member 117'' and member 266.

To prevent a hydrostatic lock from forming in cavity 140'' as the outer cylinder 119'' is retracted, a low

pressure relief valve 270 is disposed in the valve seat 252 such that any fluid captured in the extend cavity 140'' during retraction is allowed to escape.

Hydraulic fluid is supplied to the dual action sequencing valve through an opening 138'' in the end wall 117d and exists through a passage 148'' in the outer cylinder member 266. Thereafter the fluid enters a conduit 151'' through a fitting 150'' in a similar manner as in the initial embodiment, since the remainder of the hydraulic cylinder 70''' as well as cylinder 58 and the boom sections are unchanged except for the removal of the latch mechanism 56.

In the present embodiment the dual action sequencing valve 250 is employed only in the lower hydraulic cylinder 70'''. To describe the operational sequence of the dual action valve 250 it is assumed that initially the boom 20 is fully retracted.

To effect extension of the boom 20 a control is actuated such that hydraulic fluid is supplied to the lower hydraulic cylinder 70'''. The fluid enters the valve 250 through passage 138'' and flows through the passages, as indicated by the arrows in FIG. 25, exiting through the conduit 151''. The fluid is then conducted through the upper cylinder 58 and into the extend cavity 140.

As the pressure in both the hydraulic cylinders 58 and 70''' starts to rise, both cylinders exert an extending force. In this case both the inner and intermediate boom sections are free to extend, there being no latch to restrain them. However, the inner boom section 52, which is connected to cylinder 58, extends first because the upper cylinder 58 generates a substantially greater extending force than the lower cylinder 70'''. This fact can be readily determined by comparing the effective areas of the extend cavity 140 of the upper cylinder 58 (FIG. 4) which is identical in end area to cavity 140'' of FIG. 25 and cavity 258 which is considerably smaller. Although the difference in friction between the inner and intermediate boom sections which resists their extension varies, the substantial difference in the effective area of cavities 140 and 258 insures that the upper cylinder 58 and attached inner boom section 52 will extend first.

Upon complete extension of the upper cylinder 58 the pressure in the hydraulic system rises. An approximately 2000 psi the check valve 264 opens and the extend cavity 140'' of the lower hydraulic cylinder 70''' is charged with hydraulic fluid causing the lower cylinder and the attached intermediate boom section to extend. As soon as the lower cylinder 70''' has extended a sufficient distance such that the extension 254 has disengaged cavity 258, the action of spring 125e'' closes valve stem 125d'' against seat 252 preventing the collapse of cylinder 70''' in the event of damage to the upper cylinder 58 or interconnecting lines.

To retract the boom from the fully or partially extended position, hydraulic pressure is applied to the retract cavities of both cylinders as described in the initial embodiment. As the upper cylinder attempts to retract and force the fluid out of its extend cavity back through conduit 151'' into cylinder 70''', the valve stem 125d'' which is now seated in the valve seat 252, blocks the "extend fluid" from the upper cylinder, preventing the retraction of the upper cylinder 58 and attached inner boom section 52. The lower hydraulic cylinder 70''' and attached intermediate boom section 50 which is not similarly restrained, retract. As the lower cylinder 70''' approaches the end of its retract stroke, the valve

seat extension 254 engages and seals in cavity 258. The relief valve 270 is now effective to allow the fluid which becomes trapped in cavity 140'' to escape, permitting full retraction of the lower cylinder 70'''. During this portion of the retract stroke the valve stem 125d'' contacts the end wall 117d'', unseating the valve against the force of spring 125e'' and thereby releasing the "extend fluid" of the upper hydraulic cylinder 58. The upper cylinder 58 and attached inner boom section 52 now retract in response to the retract pressure in the upper cylinder, completing the retraction of the entire boom assembly 20.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, the subject matter which is regarded as the invention is set forth in the appended claims.

We claim:

1. In a telescoping boom having an outer fixed section and intermediate and inner sections that are extended and retracted by hydraulic cylinders, each of said hydraulic cylinders being connected at one end to the boom section to be extended and at the other end to the next radially outermost boom section, each cylinder including two sets of diametrically opposed lugs disposed to receive a pin between them, and means on said booms defining bosses for retaining pins received between the said lugs, said lugs cooperating with said pins and bosses to transmit the cylinder forces to the boom sections for extension and retraction.

2. In an extensible boom of the type having a tubular base section, a tubular mid section slidably received in said base section, a tubular inner section slidably received in said mid section, first hydraulic cylinder means pivotally connected to base section and disposed in said base and mid sections, second hydraulic cylinder means pivotally connected at one end to said mid section and disposed in said mid and inner sections, the improvement which comprises laterally spaced lug means radially disposed on opposite sides of each of said cylinders, means defining alignable openings in said base and in said mid and inner boom sections, first pin means insertable through the apertures in said mid section when in alignment and between said lug means of said first cylinder connecting said first cylinder in driving engagement with said mid section, and second pin means insertable through the apertures in said inner section and between said lug means of said second cylinder to connect said second cylinder in driving relation with said inner section.

3. The apparatus of claim 6 including an auxiliary section slidably received in said inner section and disposed in a surrounding relationship to said second cylinder connector means secured to the outward end of said cylinder, third removable pin means insertable through alignable openings in said connector means and said auxiliary section; and retaining means for retaining said second pin means in a partially inserted position in the aligned apertures of said base, mid and inner sections but out of engagement with said lugs whereby said base, mid and inner sections are locked together and said lugs on said second cylinder are disengaged whereby energization of said second cylinder causes extension of said auxiliary section.

4. The apparatus of claim 2 wherein said lateral spacing between said lugs is defined by straight vertical surfaces and said pin means vertically receivable therein have a diameter less than said spacing to permit relative

sliding and tilting motion between said lugs and said pin means upon deflection of the boom under load.

5. The apparatus of claim 2 wherein each cylinder includes a casing and a rod and wherein said lugs are located at the rear portion of each casing.

6. In a telescoping boom having concentric sections including an outer fixed section and intermediate and inner sections that are extended and retracted by hydraulic cylinders, each of said hydraulic cylinder being connected at one end by pin means to the boom section to be extended and at the other end to the next radially outermost boom section, wherein the improvement comprises an extendible auxiliary boom section within said inner section, pin and aperture means effective to alternately lock said inner and auxiliary sections together when said auxiliary section is either in a fully extended position or in a fully retracted position, said pin and aperture means also being effective to connect the hydraulic cylinder associated with said inner section to the auxiliary section for extension and retraction thereof, and the pin means associated with said inner section being movable to a position where the associated hydraulic cylinder is disconnected therefrom and said inner, intermediate and outer sections are locked together.

7. A method of extending a crane boom, having at least two extendible telescoping sections mounted within a fixed section by means of a single hydraulic cylinder having its driving end attached to said fixed section, comprising the steps of connecting the driven end of said cylinder to the first section to be extended, connecting the remaining sections to said fixed section, extending said first section by extending said hydraulic cylinder, locking said first section to a second section, disconnecting said driven end of said cylinder, retracting said cylinder, connecting the driven end of said cylinder to said second section, disconnecting said second section from said fixed section, and extending said second section by extending said hydraulic cylinder.

8. A method of extending a telescoping boom having concentric sections including an outer fixed section, intermediate, inner and auxiliary sections wherein a first hydraulic cylinder has its driving end connected to said fixed section and its driven end to said intermediate section, a second hydraulic cylinder has its driving end connected to said intermediate section and its driven end to said inner section comprising the steps of connecting the driven end of said second cylinder to the auxiliary section to be extended, disconnecting the driven end of said second cylinder from said inner section, locking the remaining sections to said fixed section, extending said auxiliary section by extending said second hydraulic cylinder, locking said auxiliary section to the inner section, disconnecting said driven end of said second hydraulic cylinder, retracting said second hydraulic cylinder, connecting the driven end of said second hydraulic cylinder to said inner section, unlocking said inner section from said remaining sections, extending said inner section by extending said second hydraulic cylinder, unlocking said intermediate section from the fixed section in response to complete extension of said inner section, and extending said intermediate section by extending said second hydraulic cylinder.

9. In a telescoping boom having an outer fixed section and at least movable intermediate and inner boom sections, means for connecting a first power cylinder

between the outer and intermediate boom sections for extending the latter, means for connecting a second power cylinder between the intermediate and inner boom sections for extending the latter, each of the cylinders including telescoping rod and case elements defining cavities effective to cause extension and retraction of the cylinders in response to fluid pressure, fluid supply means for directing fluid under pressure successively through the first and second cylinders, latch means for preventing extension of the intermediate boom section until the inner boom section has been extended, sequencing valve means interconnecting the extension cavities of the cylinders for preventing fluid flow from the extension cavity of the second cylinder to the extension cavity of the first cylinder in response to fluid pressure in the retraction cavities of the cylinders until said first cylinder has been substantially completely retracted, said cylinder connecting means for each cylinder includes diametrically opposed sets of spaced lugs disposed to receive vertical pins between them, and means on said movable boom sections defining bosses for retaining said vertical pins and for cooperating with said pins and lugs to transmit extension and retraction forces between said boom sections cylinders and latch means.

10. The boom of claim 9 wherein said spacing between said lugs is defined by straight vertical surfaces, and said vertical pins have a diameter less than said spacing for permitting relative sliding motion between said lugs and said vertical pins upon deflection of the boom under load.

11. The boom of claim 9 wherein said lugs are located on the rear portion of the cylinder case elements.

12. The boom of claim 9 wherein an auxiliary boom section is telescopically received within said inner boom section, a set of apertures in said outer intermediate and inner boom sections in alignment for inserting said vertical pins associated with said second cylinder when said boom sections are retracted, connector means secured to the outward end of said second cylinder, alignable openings in said connector means auxiliary and inner boom sections, a first removable pin insertable through alignable openings in said connector means and said auxiliary section to drivingly connect said second cylinder to said auxiliary boom section, and retaining means for retaining said vertical pins in a partially inserted position to disengage said second cylinder and lock said inner intermediate and outer boom sections together.

13. The boom of claim 12 wherein a second removable pin is insertable in alignable openings to lock said inner and auxiliary boom sections together when said auxiliary section is either in an extended or retracted position.

14. In a telescoping boom having concentric sections including an outer fixed section and extendible intermediate and inner sections that are extended and retracted by a hydraulic cylinder having one end pivotally connected to the fixed outer section, wherein the improvement comprises spaced lug means radially disposed on opposite sides of the other end of the cylinder, apertures in the intermediate and outer boom sections that are in alignment when said intermediate section is retracted, pin receiving bosses on the intermediate section, vertical pins insertable through said apertures and between said lug means to connect the other end of said cylinder to the intermediate section, and retaining means for retaining said vertical pins in a partially inserted position in said apertures out of engagement with said lug means and locking the intermediate and outer boom sections together.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,770,138
DATED : November 6, 1973
INVENTOR(S) : PAUL A. CHALUPSKY et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 4, line 63, change "3" to --38--.
Col. 11, line 6, change "exists" to --exits--.
Col. 12, line 50, change "6" to --2--.
Col. 13, line 27, change "telescopigng" to --telescoping--.
Col. 14, line 42, change "axuiliary" to --auxiliary--.

Signed and sealed this 29th day of April 1975.

(SEAL)

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks