United States Patent

Brown et al.

[15] **3,658,189**

[45] **Apr. 25, 1972**

[54] HYDRAULIC EXTENSIBLE BOOM STRUCTURE

[72] Inventors: **Archer W. Brown,** Minneapolis; **James L. Montgomery,** St. Paul; **Charles W. Wienke,** North St. Paul; **Alfons Roskowinski,** St. Paul; **William A. Braddock,** Bloomington, all of Minn.

[73] Assignee: **American Hoist & Derrick Company,** St. Paul, Minn.

[22] Filed: **Jan. 6, 1970**

[21] Appl. No.: **872**

[52] **U.S. Cl.** **212/55,** 91/168, 92/52

[51] **Int. Cl.** **B66c 23/06**

[58] **Field of Search** 212/55; 52/115; 91/167, 168; 92/51-53

[56] **References Cited**

UNITED STATES PATENTS

3,396,852	8/1968	Balogh et al.	212/55 X
3,212,604	10/1965	Garnett	212/55 UX
3,398,645	8/1968	Nansel	52/115 X
3,188,917	6/1965	Quayle	91/168
2,888,149	5/1959	Troche	52/115 X
3,259,251	7/1966	Stauffer	212/55

FOREIGN PATENTS OR APPLICATIONS

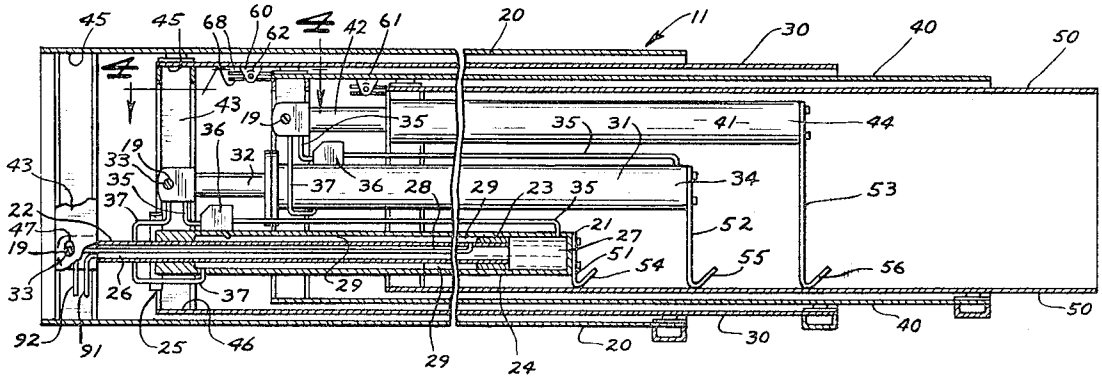
1,282,268	11/1968	Germany	212/55

Primary Examiner—Joseph Wegbreit
Assistant Examiner—Merle F. Maffei
Attorney—Burd, Braddock & Bartz

[57] **ABSTRACT**

A plurality of telescoping boom sections are powered by double acting hydraulic piston-cylinder motors, each motor having a hollow piston rod pivotally mounted to the inward end of an inward boom member, a piston on the rod, and a cylinder fixedly and rigidly mounted at its inward rod end to an inward end of the next adjacent nesting outward boom member. Hydraulic fluid to move the boom sections to extended and retracted positions is fed from the pivoted end of each of the piston rods, and along those rods to "extend" and "retract" cylinder chambers on opposite sides of the piston. "Extend" and "retract" conduits from these chambers on each inward motor open from opposite ends of each inward cylinder to carry this fluid to and from the next outward piston rod. A normally closed hydraulic valve is situated in each "extend" conduit, and this valve is opened to provide a flow path to its outward motor only when the inward motor is fully extended. When two adjacent inward boom sections reach their extended positions with respect to each other, they are latched to each other against further longitudinal movement. Each such latch is mechanically released by the arrival at its fully retracted position of the boom section next outward from the latched pair.

5 Claims, 9 Drawing Figures



PATENTED APR 25 1972

3,658,189

SHEET 1 OF 3

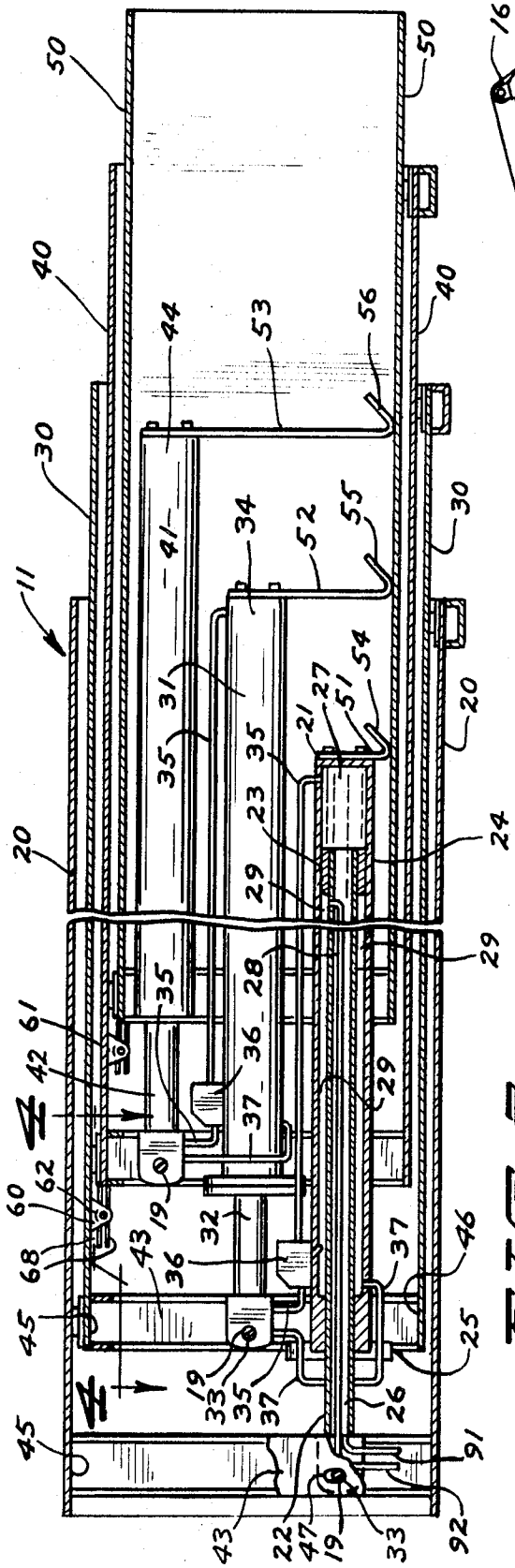


FIG. 2

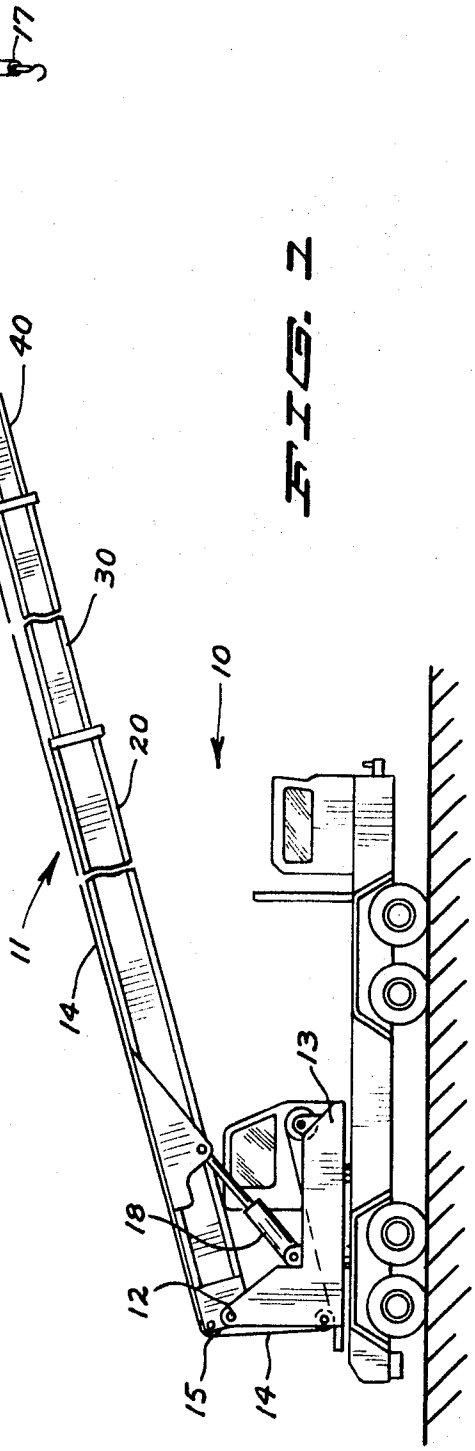


FIG. 1

INVENTORS
ARCHER W. BROWN
JAMES L. MONTGOMERY
BY CHARLES W. WIENKE
ALFONS ROSKOWINSKI
WILLIAM A. BRADDOCK
Burd Braddock & Bartz
ATTORNEYS

FIG. 3

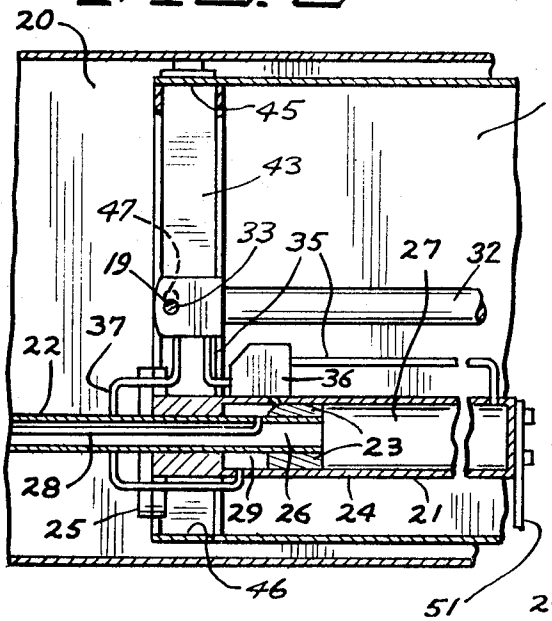


FIG. 6

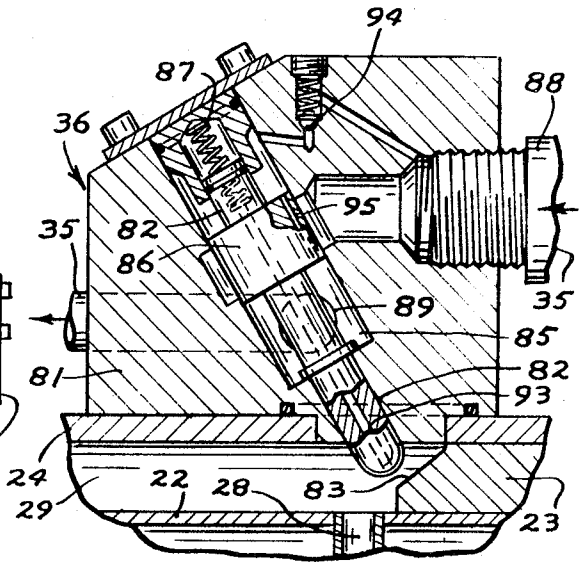
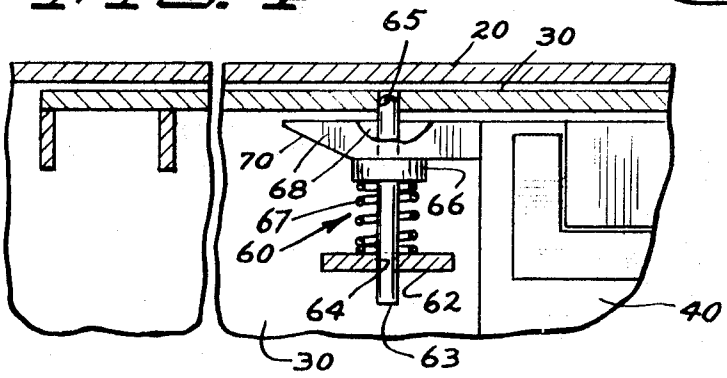


FIG. 4



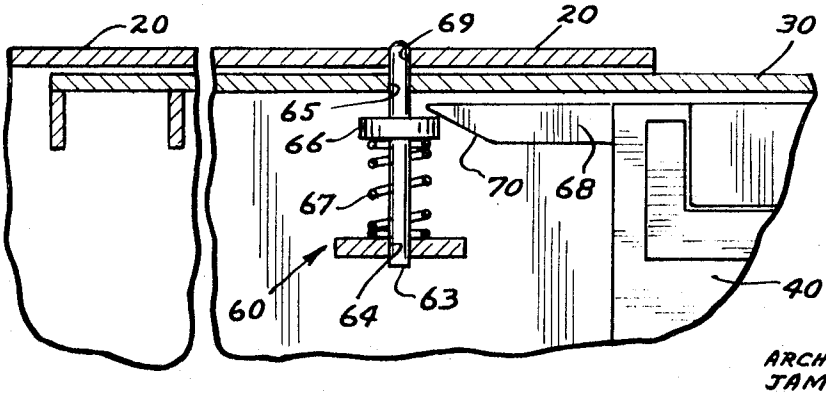


FIG. 5

INVENTORS
ARCHER W. BROWN
JAMES L. MONTGOMERY
BY CHARLES W. WIENKE
ALFONS ROSKOWINSKI
WILLIAM A. BRADDOCK
Burd Braddock & Bartz
ATTORNEYS

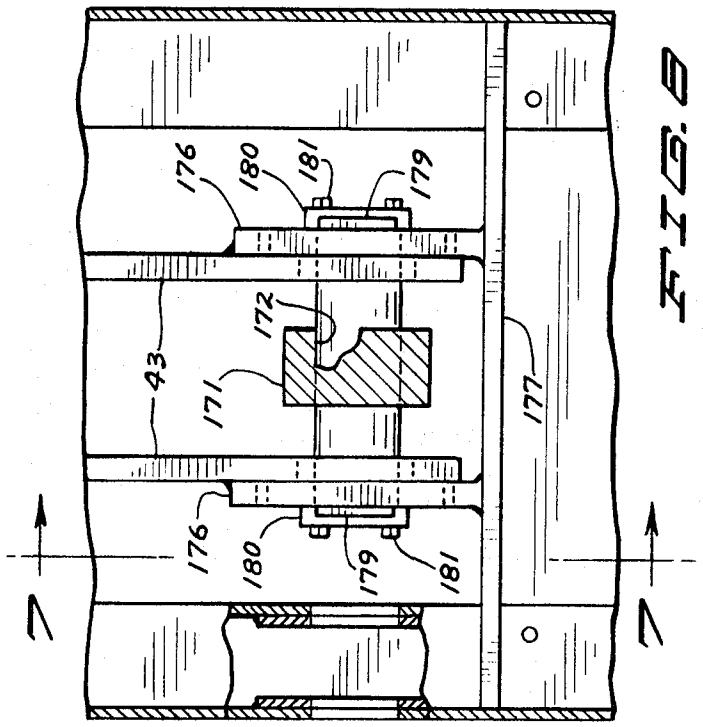


FIG. 8

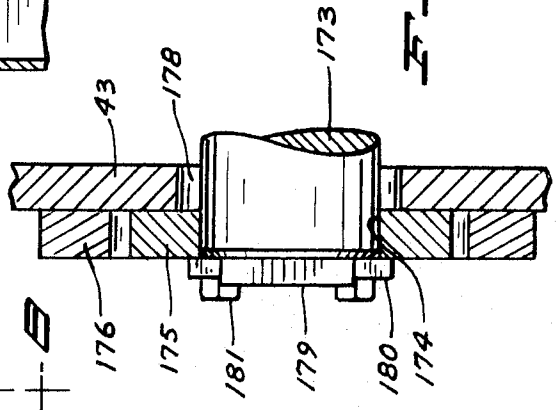


FIG. 9

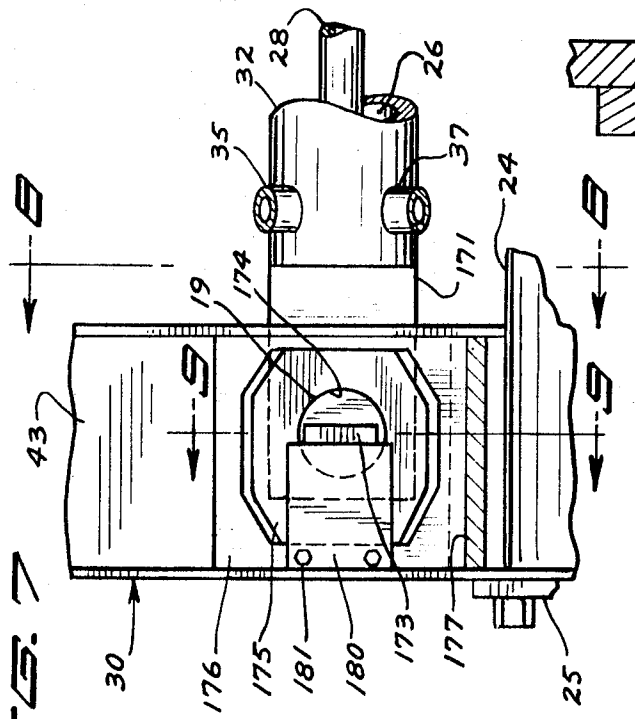


FIG. 7

INVENTORS
ARCHER W. BROWN
JAMES L. MONTGOMERY
BY CHARLES W. WIENKE
ALFONS ROSKOWINSKI
WILLIAM A. BRADDOCK
Burd Braddock & Bartz
ATTORNEYS

HYDRAULIC EXTENSIBLE BOOM STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATION

The inventions disclosed in this application are related to the application of Archer W. Brown, James L. Montgomery and Lorraine V. Erkenbrock for BOOM ASSEMBLY, filed June 13, 1969, Ser. No. 833,079, and that disclosure forms a part of this one.

BACKGROUND OF THE INVENTION

This invention has relation to cranes with hydraulically extensible booms in which the boom sections extend in sequence with the inwardmost movable section initially extending fully and then each next adjacent outward section extending fully in its turn, and in which the boom sections retract in sequence with the outwardmost section first retracting fully and then each next adjacent inward section retracting in its turn. Since the inwardmost sections are also the outer, larger and hence stronger sections, this sequence is desirable to insure maximum strength or load lifting ability at every different boom length.

In any hydraulically extensible boom structure, provision must be made to accommodate deflection in the vertical plane as the boom is extended and under load conditions. This invention had to do with means to support the hydraulic motors in such a manner as to accommodate this deflection without binding developing in such motors.

It has been suggested in the prior art (U.S. Pat. Nos. 3,171,545 and 3,398,645) to utilize purely mechanical latch means operable upon movement of the boom sections with respect to each other, to accomplish the sequencing of the boom extension and retraction. This system has the disadvantage that a change from boom extension to boom retraction made before full extension is reached creates an unlatched situation in which two sections can each simultaneously move in inward direction. This results in a decrease in the maximum boom strength and lifting ability.

In the prior art (U.S. Pat. No. 3,315,821, for example), fluid motors have been pivotally mounted at their opposite ends to adjacent telescoping boom sections. These structures, however, have necessarily used hydraulic lines which extend longitudinally of the interior of the boom structure and outside of the hydraulic motors in positions where they must be continually reeled in and paid out as the boom extends and retracts. Such structures are inconvenient, troublesome, and, in the case of failure due to wear or rupture because of fouling of the lines, even dangerous.

Before the present invention, U.S. Pat. No. 2,984,374 suggested pivotally mounting fluid motors at each of their opposite ends to be adjacent slidably mounted boom sections and suggested driving an outward fluid motor through conduits passing along the length of the piston rod of the inward motor, thus eliminating the need for hose reels. This structure, however, lacked the positive control over the sequencing of the extension of the boom sections and their retraction.

In U.S. Pat. No. 3,300,060, a hydraulic conduit is brought out, using a system of conduits and reels and sheaves, from each of the ends of each of several fluid motors utilized to extend and retract telescoping boom sections, and pressure activated sequencing valves are used to block the passage of fluid through an outwardly disposed fluid motor until such time as its adjacent inward motor has become fully extended and a critical pressure builds up in that system. This arrangement has the obvious disadvantage that, should the inwardmost telescoping section be called upon to carry an appreciable overload as it is being extended, the pressure activated sequencing valve would operate to remove the disability on the outward fluid motors to operate, thus destroying the ability to control the sequence of boom extension. Further, the maintenance of proper adjustment on such pressure activated release valves as they are subjected to wear is difficult, time consuming and expensive.

SUMMARY OF THE INVENTION

In order to overcome the above difficulties, a crane having telescoping extensible boom sections is provided with a plurality of fluid motors each having a hollow piston rod pivotally mounted to the inward end of the inwardmost of two adjacent telescoping sections and a cylinder fixedly and rigidly mounted at its inward rod end to the inward end of the other section. A piston is situated in the cylinder on the piston rod to be at position adjacent the closed end of the cylinder when the adjoining boom sections are in their retracted condition and to be adjacent the rod end of the cylinder when these sections are in their extended conditions with respect to each other. A "retract" passage is provided in each such hollow piston rod from adjacent its pivoted connection to position adjacent its piston where it is open to a "retract" chamber defined by the interior walls of the cylinder, the piston and the closure at the rod end of the cylinder. On the inwardmost fluid motor, this "retract" passage is supplied with pressure through the pivoted rod end from an outside source. On all but the outwardmost fluid motor, a "retract" conduit leads from the "retract" chamber adjacent its closed end to the "retract" passage in the hollow piston rod of the next adjacent outward fluid motor.

Each hollow piston provides an "extend" passageway open to a source of fluid under pressure adjacent the pivoted end of the piston rod, and open through the piston into a closed end "extend" chamber defined by the interior wall of the cylinder, the piston and the closed end of the cylinder. In every fluid motor except the outwardmost one, an "extend" conduit is open from the "extend" chamber at position immediately adjacent the closed end of the cylinder to the "extend" passageway at the inward pivoted end of the piston rod of the next outwardly adjacent fluid motor.

A normally closed fluid valve is located in each such "extend" conduit, such valve being located and constructed so as to be moved to open position responsive to arrival of the piston in adjacent relationship to the inward rod end of the cylinder of its inwardly adjacent fluid motor.

A mechanical latch or interlock is provided between all but the two outwardmost adjacent telescoping boom sections, the interlock becoming effective when the boom sections reach their extended position with respect to each other and the next outward boom section begins its movement away from the extended pair. This mechanical latch or interlock is effective in preventing relative longitudinal movement between the boom sections of such an extended pair until such time as this next outward section resumes its position in fully retracted relationship to the outwardmost section of the pair.

Inasmuch as the outward ends of all the cylinders are situated inside of the inner or interior but outwardmost boom section when all of the boom sections are fully retracted, none of these outward cylinder ends except the outwardmost one can be supported fixedly with respect to the boom section to which its inner end is rigidly connected. To support the weight of these outward ends, skids are provided so that such weight will be supported at any one time either on the interior bottom wall of its own boom section or on the interior bottom wall of one of the smaller inner but outward nested boom sections. All but the outermost skid will slide freely from one to the other of the boom sections as the sections are extended and retracted.

The support of each cylinder in rigid relationship to the inward end of the nested boom section to which it is connected minimizes the deflection necessary in the piston rod extending into that cylinder to accommodate the deflection of the nested boom sections of the telescopic boom under load which is designed into the machine. This deflection is also accommodated for in each fluid motor by a pivotal connection between the inward end of each piston rod and the inward end of the boom section to which the rod is fastened; such pivotal connection providing for vertical transverse movement of the rod end with respect to the boom section.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a foreshortened side elevational view of a truck mounted crane having a hydraulically extensible boom illustrated in its extended position;

FIG. 2 is an enlarged, foreshortened, vertical, longitudinal sectional view of the extensible boom in FIG. 1, but showing the boom sections in their retracted conditions;

FIG. 3 is a further enlarged fragmentary sectional view as in FIG. 2 but showing the relationships between a piston, a cylinder, and a normally closed hydraulic valve in its open condition when two adjacent boom sections are in their extended positions with respect to each other;

FIG. 4 is an enlarged fragmentary sectional view taken on the line 4—4 in FIG. 2 showing the relationship of a mechanical latching means to three adjacent boom sections when the two outward boom sections are in their retracted positions with respect to each other;

FIG. 5 is a view of the parts as shown in FIG. 4 but with the two inward boom sections in fully extended relationship to each other and with the outer boom section partly extended,

FIG. 6 is an enlarged vertical sectional view of the normally closed hydraulic valve of FIG. 3 taken in the plane of FIG. 3, but showing the valve in its closed condition;

FIG. 7 is an enlarged fragmentary side elevational view of a modified structure for pivotal connection of a piston rod to an inward end of a boom section as it would appear substituted for the pivoted piston rod-boom section structure shown in FIG. 3;

FIG. 8 is a fragmentary vertical sectional view taken on the line 8—8 in FIG. 7; and

FIG. 9 is a fragmentary vertical sectional view taken on the line 9—9 in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A crane 10 has a hydraulically extensible boom 11 pivotally mounted as at 12 to a crane turntable 13. A load line 14 runs from a drum on the turntable and over appropriate sheaves including a sheave 15 mounted at the base of the boom assembly and a sheave 16 mounted at the point of the boom assembly to control a load hook 17 or any other necessary or desired load carrying attachment.

A base or inwardmost first boom section 20 of the boom 11 can be raised or lowered about the boom pivot point 12 through the instrumentality of a hydraulic cylinder-piston motor 18.

Telescopically nested within this inwardmost boom section 20 in consecutive order from inward toward outward location are second boom section 30, third boom section 40, and outwardmost fourth boom section 50. Thus the outwardmost boom section 50 is at the same time the inner boom section since it nests telescopically within each of the other sections. Hydraulic cylinder-piston motors 21, 31 and 41 power the extension and the retraction of adjacent boom sections with respect to each other. The motor 21 is connected between the inwardmost base or first boom section 20 and the next adjacent outward second boom section 30, the motor 31 is connected between the second boom section 30 and the next outward adjacent third boom section 40, and the hydraulic motor 41 is connected between boom section 40 and the outwardmost adjacent fourth boom section 50. Each such hydraulic motor includes a cylinder, a piston and a hollow piston rod. These rods are designated 22, 32 and 42, respectively, and each such rod is pivotally mounted to the inward end of the inward one of its pair of boom sections as at 19. As best seen in FIGS. 2 and 3, this is accomplished by slidably supporting pivot pins 33 in slotted vertical side plates 43, 43 which are welded into top and bottom walls of the boom sections as at 45 and 46, respectively. These side plates 43, 43 are provided with slotted openings 47 which allow the rods to move vertically transversely of the boom sections to accommodate the vertical deflection built into boom sections under load by allowing each piston rod to maintain its concentric longitudinal alignment with its cylinder.

Although each of these piston rods carries a piston, only the piston 23 in hydraulic motor 21 is shown.

The cylinders in sliding, driving relationship to each piston and piston rod of each motor are designated 24, 34 and 44, respectively. The inward, rod end of each of these cylinders is fixedly mounted to the inward end portion of the outward boom section of the boom section pair driven by the motor of which the cylinder is a part. Thus cylinder 24 is fixedly and rigidly mounted to the inward end of boom section 30 as at 25.

Each of the hollow piston rods is provided with an extend passageway or first conduit 26 open from outside of the piston rod adjacent the pivoted end thereof to an extend or first chamber 27 defined by the interior wall of the cylinder, the piston and the closed end of the cylinder. An extend or second conduit 35 is open from this extend chamber 27 in cylinders 24 and 34 at position adjacent the closed end thereof to the extend passageways 26 adjacent the pivoted ends of hollow pistons 32 and 42, respectively. Each of these extend conduits 35 has a normally closed hydraulic valve 36 therein fixedly mounted on the cylinder from which the conduit extends but at position adjacent the rod end thereof. This is best seen in FIGS. 2 and 6.

Each of the hollow piston rods 22, 32 and 42, is also provided with a retract passageway or third conduit 28 extending from outside of the piston rod adjacent the pivoted end thereof, through the wall of the piston rod at position adjacent the piston and into a retract or second chamber 29 defined by the interior wall of the cylinder, the piston and the cylinder closure at the rod end of the cylinder. On all but the outwardmost fluid motor, a retract or fourth conduit 37 leads from this retract chamber 29 at position adjacent the rod end of the cylinder to the retract passageway 28 adjacent the pivoted end of the hollow piston rod of the next adjacent outward fluid motor.

The outward ends of each of the cylinders 24, 34 and 44 are supported on skids 51, 52 and 53, respectively. The skids are provided with inclined feet 54, 55 and 56, respectively, and the feet 54 and 55 are situated to be in sliding relationship to the interior surface of the boom sections situated outwardly from the section to which the foot's cylinder is attached. The angle of incline will be such that the foot will slide easily from contact with one outward boom section to the other, thus to always support its associated cylinder with respect to some portion of the boom assembly.

Mechanical latches or interlocks 60 and 61 are provided to lock the first and second boom sections against longitudinal movement with respect to each other and to lock the second and third boom sections against longitudinal movement with respect to each other, respectively, after each such pair has reached the limit of their travel away from each other, and to maintain such interlock until such time as the immediately adjacent outward boom section is completely retracted. The relationship of the interlock mechanism to the overall positioning of the boom sections is best seen in FIG. 2 and the details of the interlock 60 are best shown in FIGS. 4 and 5. The interlock 61 is identical in operation to that of the interlock 60.

The interlock mechanism 60 as seen in FIG. 4, is at right angles to the mechanism as seen in FIG. 2. In FIG. 4, the inwardmost base or first boom section is shown in relative relationship to the second boom section 30 and the third boom section 40 when these two latter boom sections are completely retracted. An ear 62 is integral with the top wall of the boom section 30 and extends downwardly therefrom. A latch bolt 63 is slidably mounted in an opening 64 provided in the ear 62 and in an opening 65 in the side wall of the boom section 30. The latch bolt 63 is provided with an integral collar 66 and a coil spring 67 acting on the collar and on the ear 62 tends to move the bolt in direction through the opening 65 in the side wall of the boom section 30. A pair of spaced parallel fingers 68 extend integrally outwardly from third boom section 40, and are situated on either side of the bolt 63 to limit movement of the collar 66 and consequently of the bolt when the parts are all in their fully retracted positions.

As will be explained in detail later, as the boom structure extends, the first movement is between the second boom section 30 and the first or base boom section 20. When these boom sections arrive at the limit of their travel with respect to each other, the bolt 63 and the opening 65 in the second boom section 30 will be in alignment with an opening 69 in base boom section 20. At this point, hydraulic fluid will be introduced into the "extend" elements of the second hydraulic motor 31 in a manner to be described later, and this will cause the third boom section 40 to begin to move in outward direction with respect to the second boom section 30. This will bring the fingers 68, 68 into clearing relationship with the collar 66, thus letting the spring 67 force the bolt 63 to position in engagement with both boom section 20 and boom section 30 through the openings 69 and 65, respectively, thus preventing further longitudinal movement of each with respect to the other. This relationship of the parts is seen in FIG. 5.

These two boom sections will remain locked with respect to each other until such time as the third boom section 40 again comes into completely retracted relationship with respect to the second boom section 30, at which time inclined ramp surface 70 of the fingers 68 will lift the collar 66 and consequently the bolt 63 into clearing relationship with the opening 69 in the boom section 20. Sections 20 and 30 will then be free to move longitudinally with respect to each other, and the section 30 will begin to telescope into base section 20.

As best seen in FIG. 6, the normally closed hydraulic valve 36 includes a base casting 81 which is mounted on the wall of cylinder 24, and has a valve stem 82 slidably mounted therein to extend through the cylinder and into aligned operative relationship to a beveled cam surface 83 provided on the piston 23. A portion of the base casting 81 is cut away to provide an inlet extension 88 to the second conduit 35 and also an outlet extension 89 thereof, both of said extensions opening into a valve chamber 85. A valve spool 86 is integral with valve stem 82 and is slidably mounted in the valve chamber to be in blocking relationship to the inlet extension 88 of the conduit 35 when controlled by a coil spring 87, and to be in clearing relationship to the inlet when valve stem 82 has been moved upwardly against the action of the spring 87 by the cam surface 83 of the piston 23, thus to allow passage of hydraulic fluid through the valve chamber 85 and the conduit 35.

MODIFIED ROD PIVOT STRUCTURE

A modified form of piston rod pivotal support structure is shown in FIGS. 7, 8 and 9. As pointed out above, it is a feature of the invention that the cylinder of each fluid motor is rigidly mounted at its inward end to the inward end of the outward boom section of an adjacent pair, and its piston rod is pivoted at its inward end to the inward end of the inward boom section of that pair in such a manner that the pivot point can slide transversely of the boom section in a vertical plane as necessary to compensate for the deflection of one boom section with respect to the other under load conditions. In the main form of the invention, this was shown to be accomplished by use of a slotted opening 47 in which a rod pivot pin 33 is slidably mounted. This structure is effective for its intended purpose, but the structure of FIGS. 7, 8 and 9 will greatly improve the wear characteristics of this pivotal connection.

The parts shown in these figures which find an exact counterpart in FIGS. 1 thru 6 are similarly numbered. For example, side plates 43, 43, hollow piston rod 32, first conduit 26 and its associated second conduit 35, third conduit 28, and its associated fourth conduit 37, and second boom section 30 in which the piston rod 32 is pivotally mounted as at 19.

The piston rod 32, as seen in FIGS. 7 and 8, is provided with an elongated flat sided rectangular end portion 171 which is provided with a pivot pin opening 172 therethrough, a pivot pin 173 extends through and fits snugly in that opening and also fits snugly into openings 174 provided in slide blocks 175. Each slide block is slidably mounted in an auxiliary side plate 176 which is welded to one of the slide plates 43 and to a cross brace 177 which extends between the outer side walls of the second boom section 30 as best seen in FIG. 8.

As seen in FIGS. 7 and 9, the slide blocks 175 can move in transverse direction in the vertical plane in direction transverse to the longitudinal axis of the boom section 30, but cannot move longitudinally with respect to that section. Thus, the inward end of the piston rod 32 will have similar movement capacity since it is snugly supported on pivot pin 173 which in turn is snugly supported in the slide block 175. It is to be noted a slotted opening 178 is provided in each of the side plates 43, 43 to allow movement of the pivot pin 33 without interference from the side plates.

The pivot pin is retained in the proper position in respect to the slide blocks and the end portion 71 of the rod 32 through the instrumentality of rectangular bosses 179, 179 integral with and extending outwardly from the opposite ends of the pivot pin and through the instrumentality of retainer plates 180, 180 which are fastened to the auxiliary side plates 176, 176 as at 181 and prevent rotation of the pivot pin with respect to the slide blocks and also prevent longitudinal movement with the pin with respect to the piston rod 32.

As best seen in FIG. 5, the inward end of the cylinder 24 is rigidly mounted on the inward end of the boom section 30 as at 25. Its associated piston rod 22 will be similarly pivotally mounted to the boom section 20, but this structure is not shown.

OPERATION

Assuming the telescoping boom structure to be in its fully retracted position as seen in FIG. 2, hydraulic fluid under pressure from a source not shown is introduced through an extend supply conduit 91 into the extend passageway or first conduit 26 of the hollow piston rod 22 at a point adjacent its pivotal connection 19 to base boom section 20. Retract passageway third conduit 28 is connected to a retract supply conduit 92 which is initially open to allow hydraulic fluid to be expelled to a reservoir which is not shown. The pressure of the hydraulic fluid from the extend supply conduit 91 and into the first conduit 26 is transmitted through piston 23 into extend or first chamber 27, and this forces the cylinder 24 in an outward direction with respect to piston 22 of the hydraulic cylinder-piston motor 21. Because this cylinder is fixedly mounted with respect to second boom section 30, this boom section will move outwardly with the cylinder. Although this same pressure will be present in the section of extend or second conduit 35 which is open to extend chamber or first 27, the normally closed hydraulic valve 36 will prevent the pressure from being transmitted further until such time as the cam surface 83 of the piston 23 comes into contact with the valve stem 82 forcing the valve spool 86 out of blocking relationship to the second conduit 35. The hydraulic fluid and pressure then pass through the remaining section of the second conduit 35 and into the first conduit in the hollow piston rod 32, and through that passageway into the first chamber in motor 31, thus forcing cylinder 34 and third boom section 40 outwardly with respect to the boom section 30.

As the boom section 40 is fully extended, action of the piston in motor 31 will cause the normally closed hydraulic valve 36 to open, thus allowing hydraulic pressure to reach the first conduit in the hollow piston rod 42 of the motor 41 causing cylinder 44 and fourth boom section 50 to move outwardly with respect to third boom section 40.

As each pair of boom sections, except the third and fourth sections, reach the limit of their outward movement with respect to each other, the mechanical latch or interlock operates to prevent further longitudinal movement between the sections of the pair, which has already been explained. Thus, when base section 20 is locked by bolt 63 against longitudinal movement with respect to second boom section 30, a reversal of the direction of flow of hydraulic fluid through extend supply conduit 91 and retract supply conduit 92 cannot result in second section 30 moving inwardly with respect to

first section **20** until such time as third section **40** is fully retracted to cause fingers **68** to lift collar **66** and bolt **63** into clearing relationship with the base boom section **20**.

To retract the boom structure, hydraulic fluid from a source of pressure not shown is introduced through the retract supply conduit **92** and extend supply conduit **91** is opened to a reservoir which is not shown. This allows the hydraulic pressure and hydraulic fluid to be transmitted through third conduit **28** of hollow piston rod **22** and into retract or second chamber **29** of the cylinder **24** of hydraulic cylinder-piston motor **21**, thus tending to cause the cylinder to be moved in a direction toward the pivoted connection of the piston rod **22**. Assuming the first boom section **20** to be latched to the second boom section **30**, as shown in FIG. **5**, there can be no movement of the cylinder **24** with respect to the piston **23**. This hydraulic pressure and the hydraulic fluid will be transmitted from second chamber **29** of the cylinder **24** through fourth conduit **37**, into the first conduit in hollow piston rod **32** and into the second chamber in the cylinder **34**. Assuming that second boom section **30** and third boom section **40** are likewise at their extended positions with respect to each other and latched together, no movement between them will take place and the hydraulic pressure and hydraulic fluid will be transmitted through similar conduits and passageway into a retract chamber in the cylinder **44**, thus causing that cylinder, and fourth boom section **50** to which it is mounted, to be forced in a retracted direction toward the pivoted end of the piston rod **42**.

When any set of boom sections are latched against movement with respect to each other, the corresponding normally closed hydraulic valve **36** will be maintained in an open position with the valve stem, such as **82**, held in the upward or "-valve open" position by the piston, such as **23**, thus allowing transmission of hydraulic fluid backward out of the preceding extend chambers and through the extend conduits and passageways, ultimately to pass to the reservoir through extend supply conduit **91**.

When the fourth boom section **50** approaches and reaches the limit of its retracted movement, the fingers of latch **61** will cause the bolt pinning the second section **30** and the third section **40** to each other to be retracted, and then the pressure already present in the third conduit of cylinder **34** of motor **31** will cause relative movement between the cylinder and its piston, thus allowing associated valve **36** to return to its normally closed position. An opening **93** is provided through valve stem **82** and valve spool **86** to allow the pressure in the retract passageway to be transmitted into the upper portion of the valve chamber **85** to balance the pressure forces on the opposite ends of the valve spool **86** so that the spring **87** will be effective to force the valve spool into position to close off the conduit **35**. Excess pressure in the upper portion of the valve chamber **85** is relieved through ball check valve **94** open from this upper portion of the valve chamber to the then discharging side **88** of the extend conduit **35**, and a bleed hole **95** is provided through the spool to equalize pressures on either side of the spool. Thus, should any residual movement of an outward hydraulic motor result in an excess of hydraulic fluid being trapped in its extend chamber, conduit and passageway, after the inward pair of boom sections are unlatched and the valve **36** is closed, this fluid can either pass out through the bleed hole **95** or can force the spool **86** to come into clearing relationship to the then discharge portion **88** of the conduit **35** to allow the fluid to escape.

Since all of the retract chambers are then under pressure, as soon as two of the boom sections are unlatched with respect to each other, there will be movement between them, and this movement will continue until they are completely telescoped with respect to each other and the next inward one of the pair is unlatched with respect to the next inward section.

Should the direction of the flow of hydraulic fluid be reversed through supply conduits **91** and **92** during this process, the boom section that was in the process of retraction would reverse its direction and be extended, and no other boom section would move relative to its adjacent boom sections until the extending section reached its maximum extension. This is because the inward sections (if any) are already extended as far as possible and are latched together, and the hydraulic fluid to the outward sections (if any) is blocked by normally closed hydraulic valve **36**.

We claim:

1. In an extensible boom having a first tubular base boom section; a second tubular boom section telescopically mounted within the first section for longitudinal movement with respect thereto, a third boom section telescopically mounted within said second section for longitudinal movement with respect to said second section; a first cylinder-piston fluid motor having a piston rod pivotally mounted and mounted for transverse movement in a vertical plane at a first inward end thereof to an inward end of said first section, a cylinder rigidly mounted at its inward rod end to the inward end of said second section, and a piston on a second outward end of said piston rod in sealing, sliding, relationship to an interior surface of the wall of said cylinder; a second cylinder-piston fluid motor having a piston rod pivotally mounted and mounted for transverse movement in a vertical plane at a first inward end thereof to an inward end of said second section, a cylinder rigidly mounted at its inward rod end to an inward end of the third section, and a piston on a second outward end of said piston rod in sealing, sliding relationship to an interior surface of the wall of said cylinder; a first conduit open through each piston rod and piston from the fastened end of the rod to the piston face opposite the piston rod; a second conduit open through the wall of the cylinder of the first motor from adjacent the closed end of said cylinder to the first conduit in the piston rod of the second motor at the fastened end of the rod; a third conduit open through the wall of each piston rod at position adjacent its piston, extending along and inside the piston rod to position adjacent its fastened end; a fourth conduit open to the third conduit adjacent the fastened rod end of the second motor and to and through the wall of the cylinder of the first motor at position adjacent the rod end thereof; and means to selectively (1) supply fluid under pressure to a first conduit and to receive fluid from a third conduit at the fastened end of the piston rod of the first motor, (2) to supply fluid to said third conduit and to receive fluid from said first conduit, and (3) to block flow of fluid from either such conduit; the improvement comprising:

a normally closed hydraulic valve in said second conduit, said valve having:

1. a base casting mounted in adjacent relationship to the rod end of the first cylinder,
2. a valve stem slidably mounted in said base casting and extending through the wall of said cylinder in position to be moved by the piston in the cylinder, and
3. a valve spool on said valve stem,

said valve spool being movable between a first condition in fluid blocking relationship to said second conduit when said valve stem is in spaced relationship to said piston and a second condition in fluid passing relationship to said conduit after said piston has contacted and moved the valve stem.

2. In an extensible boom having a base boom section; a plurality of intermediate boom sections telescopically mounted with respect to each other and within said base section; an outward boom section telescopically mounted within the outwardmost intermediate section, a cylinder-piston fluid motor attached between each pair of adjacent boom sections, each motor having a piston rod fastened to an inward end of the inward one of the pair, a cylinder mounted with respect to the outward one of the pair, and a piston on said piston rod in operative relation to said cylinder; a first conduit open through each piston rod and piston from the fastened end of the rod to the piston face opposite the piston rod, a second conduit open through the wall of each cylinder except the outwardmost one from adjacent the closed end of said cylinder to the first conduit in the piston rod of the next outward motor at

the fastened end of the rod; a third conduit open through the wall of each piston rod at position adjacent its piston, extending along and inside the piston rod to position adjacent its fastened end; a fourth conduit, except in the inwardmost motor, open to the third conduit adjacent the fastened rod end and to and through the wall of the next adjacent inward motor cylinder at position adjacent the rod end thereof; and means to selectively (1) supply fluid under pressure to a first conduit and to receive fluid from a third conduit at the fastened end of the inwardmost piston rod, (2) to supply fluid to said third conduit and to receive fluid from said first conduit, and (3) to block flow of fluid from either such conduit; the improvement comprising:

a valve casing mounted adjacent each cylinder except the outer most one;

a normally closed valve operably mounted in each such casing in normally fluid blocking relation to the second conduit which extends from its associated cylinder;

a valve operator operably connected with said valve and extending through said casing and the wall of said cylinder to be in the path of travel of the piston and piston rod combination in said cylinder, said operator being operated in response to arrival of said piston at substantially the extended limit of its travel to cause said valve to move to fluid passing relationship to said second conduit.

3. The combination as specified in claim 1 and a mechanical interlock including:

a. a locking bolt slidably mounted on the interior of the second boom section at position near the inward end thereof, said second boom section being provided with an opening to pass said bolt;

b. means to urge said bolt through said opening;

c. said first section being provided with an opening which is positioned to be in alignment with said opening in said second section when said second section is substantially fully extended with respect to said first section; and

d. camming means mounted on said third section in operative relationship to said sliding bolt to move said bolt inwardly with respect to said second boom section as said third section is fully retracted with respect thereto and to allow said bolt to move through each of said openings in said first and second sections and as said third section moves outwardly with respect to said second section.

4. The combination as specified in claim 2, and a mechanical interlock including:

a. bolt means carried on the outwardmost of each adjacent boom section pair except the outwardmost pair operative to lock said pair against longitudinal movement with respect to each other when they are in extended relationship to each other, and

b. means carried on the boom section next outward from the pair to allow said bolt means to be operative responsive to movement of said next outward section in extended direction with respect to the pair, and to move said bolt means to inoperative, unlocked relationship with respect to said pair responsive to arrival of said next outward section at fully retracted relationship to the outward section of said pair.

5. The combination as specified in claim 3 wherein:

a. a collar extends outwardly from the locking bolt;

b. an ear is integrally mounted on said second section and is provided with an opening in which said bolt is slidably mounted;

c. said urging means is constituted as a coil spring surrounding said bolt and bearing on said collar and said ear; and

d. said camming means is constituted as at least one ramped finger integral with said third section and in alignment with said collar to cause it to carry said bolt into retracted, unlocked position against the action of said spring when said third section moves into fully retracted relationship to said second section, and to allow said bolt to move toward locked position under the urging of said spring as said third section starts to move toward extended position.

* * * * *