

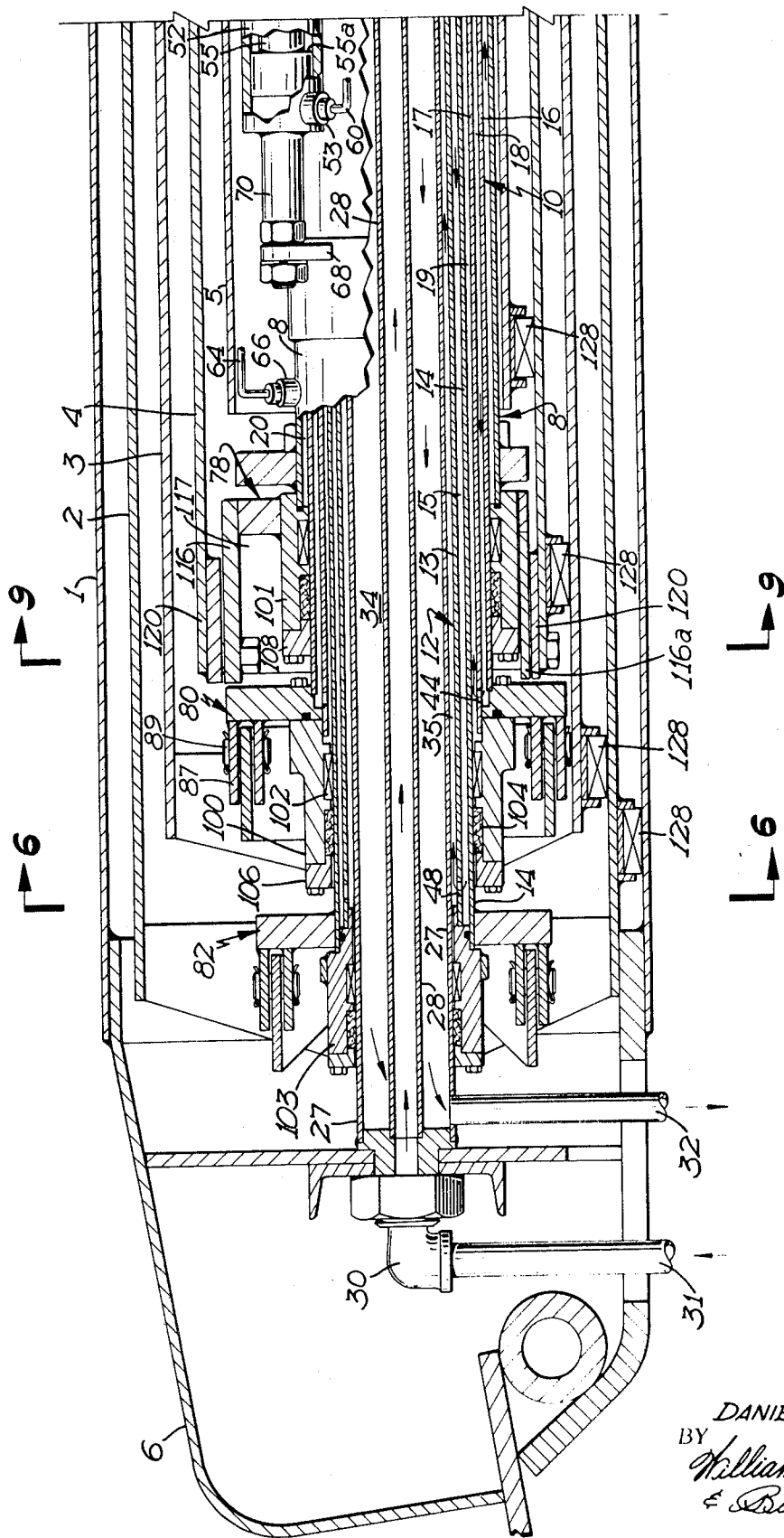
Dec. 7, 1971

D. F. PRZYBYLSKI
TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE
SECTION EXTENSIBLE BOOMS

3,624,979

Filed Aug. 25, 1969

6 Sheets—Sheet 1



FILE 1

INVENTOR.

DANIEL F. PRZYBYLSKI
BY *Williamson, Palmatier
& Bains*
ATTORNEYS

Dec. 7, 1971

D. F. PRZYBYLSKI
TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE
SECTION EXTENSIBLE BOOMS

3,624,979

Filed Aug. 25, 1969

6 Sheets-Sheet 2

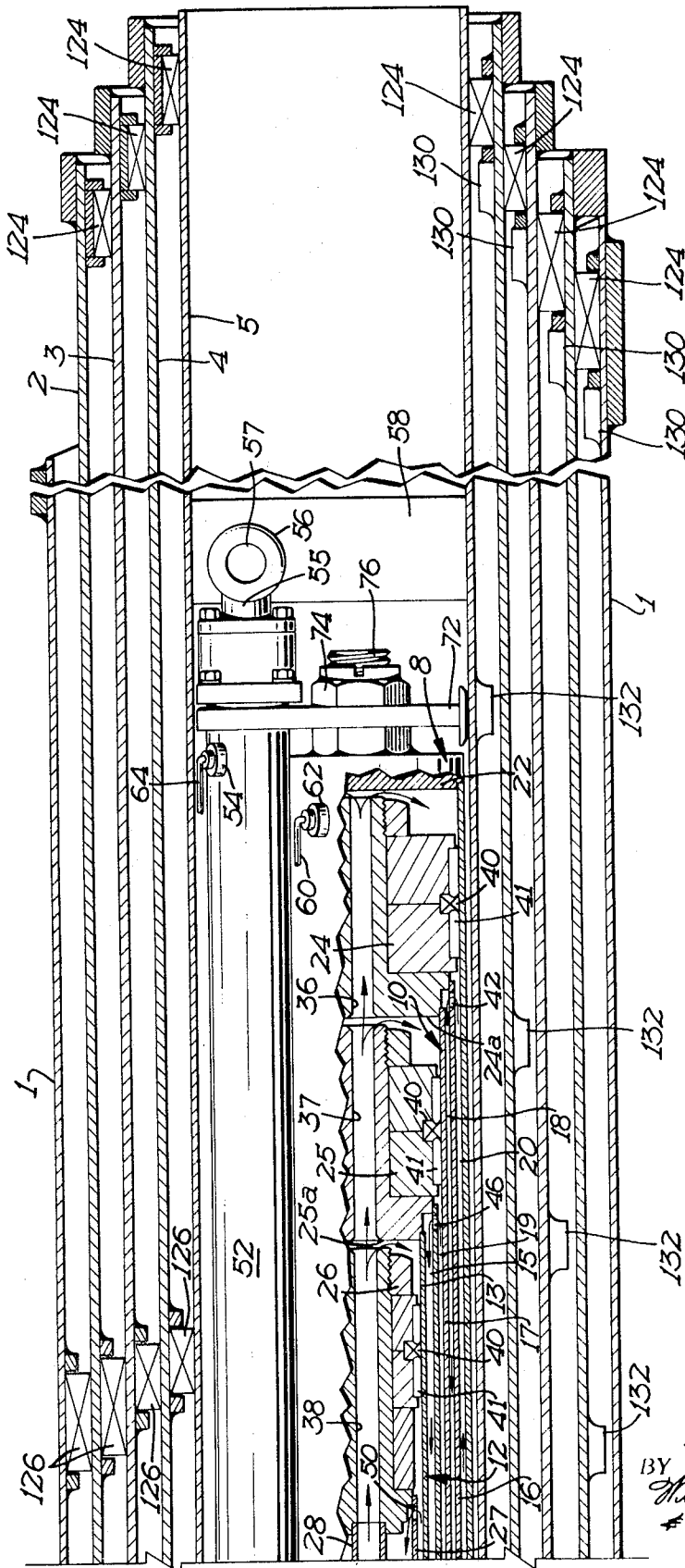


FIG 2

INVENTOR.

DANIEL F. PRZYBYLSKI

BY *Williamson, Palmatier*
* *Rains*

ATTORNEYS

Dec. 7, 1971

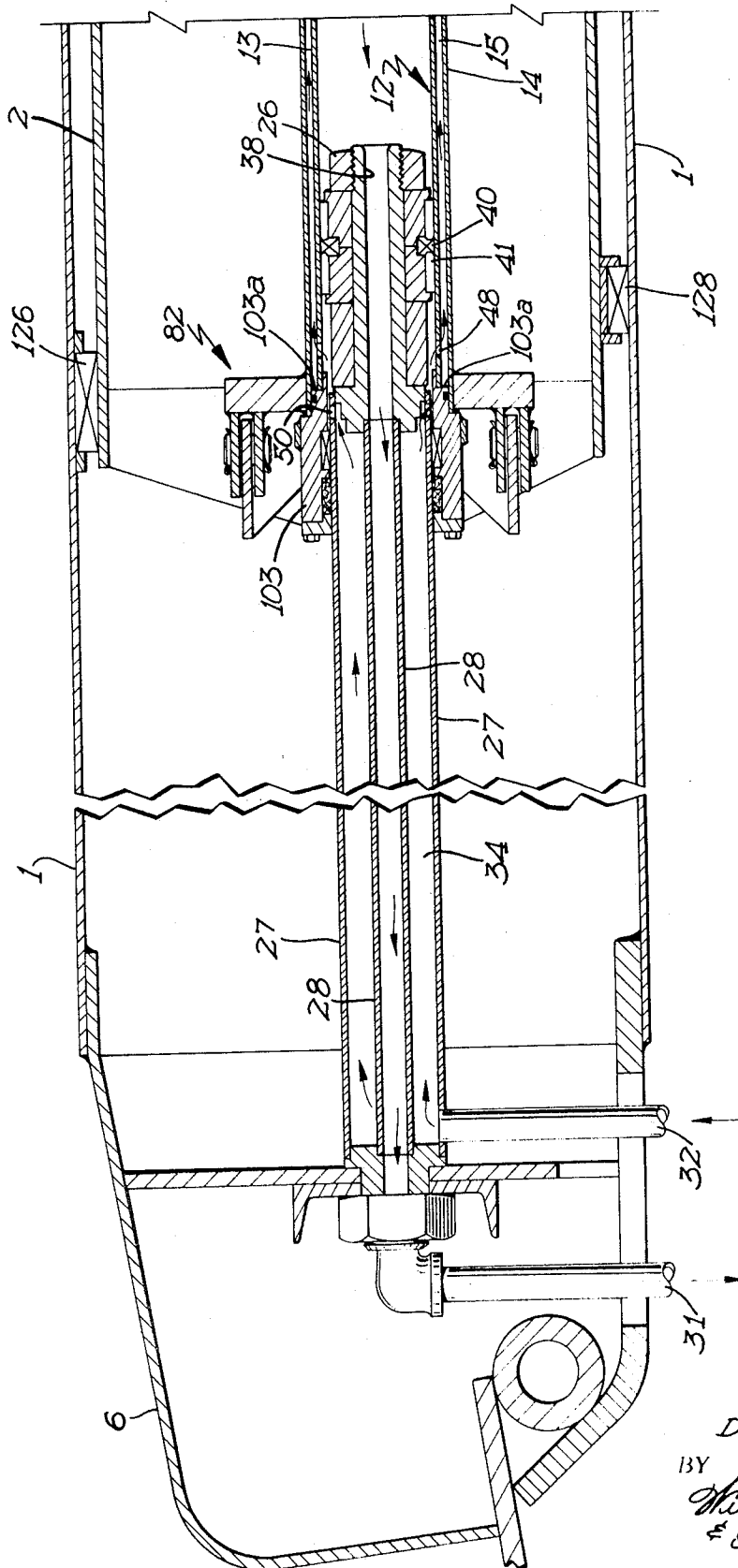
D. F. PRZYBYLSKI
J.E. GUERINER, ADVANCE

3,624,979

TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE
SECTION EXTENSIBLE BOOMS

Filed Aug. 25, 1969

6 Sheets-Sheet 5

**FILE**

INVENTOR.

DANIEL F. PRZYBYLSKI

13Y

BY *Williamson, Palmatier*
& Bains ATTORNEYS

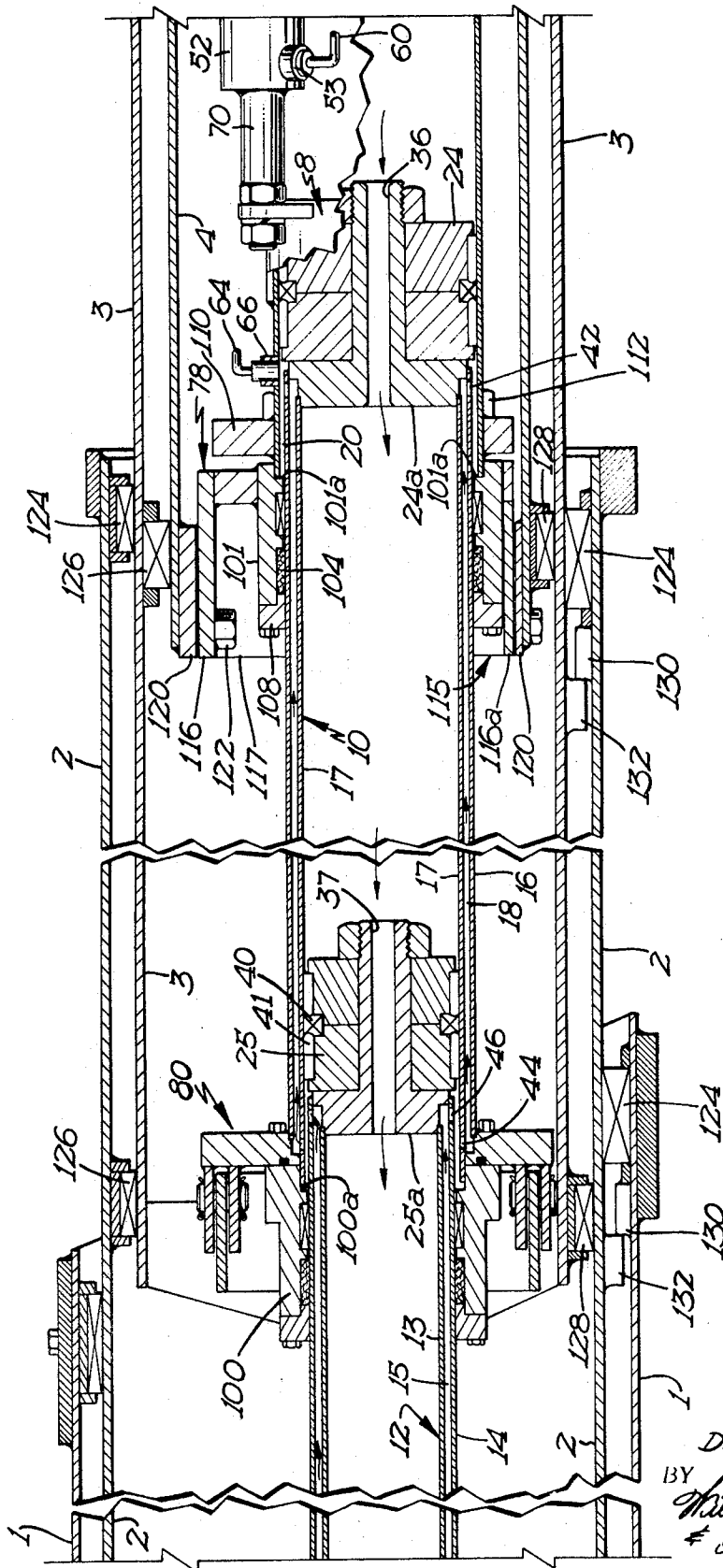
Dec. 7, 1971

D. F. PRZYBYLSKI
TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE
SECTION EXTENSIBLE BOOMS

3,624,979

Filed Aug. 25, 1969

6 Sheets-Sheet 4



FILE 4

INVENTOR.

DANIEL F. PRZYBYLSKI

BY

Williamson, Palmeter
& Bains

ATTORNEYS

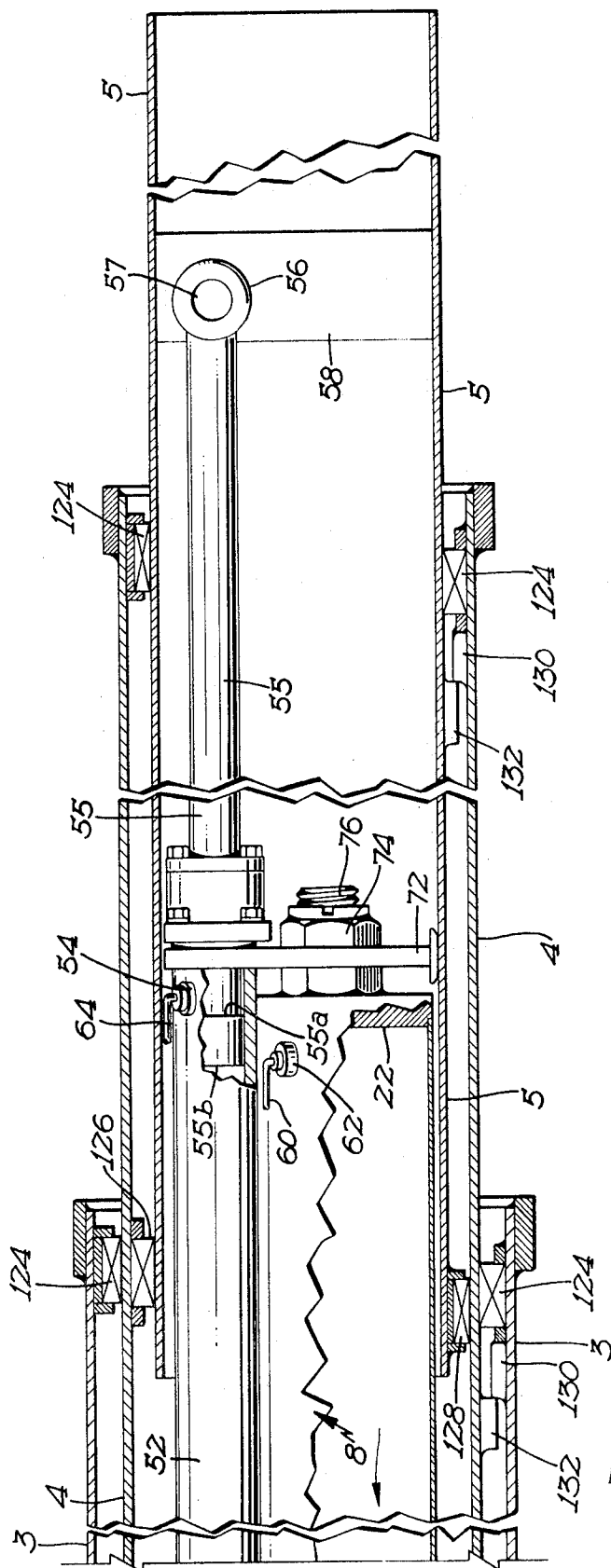
Dec. 7, 1971

971 D. F. PRZYBYLSKI 3,624
TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE
SECTION EXTENSIBLE BOOMS

3,624,979

Filed Aug. 25, 1969

6 Sheets-Sheet 5



Dec. 7, 1971 D. F. PRZYBYLSKI 3,624,979
TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE
SECTION EXTENSIBLE BOOMS
Filed Aug. 25, 1969 6 Sheets-Sheet 6

3.624.979

6 Sheets-Sheet 6

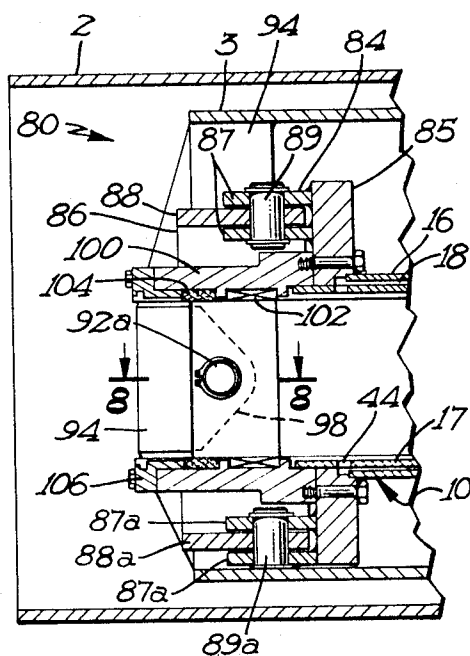
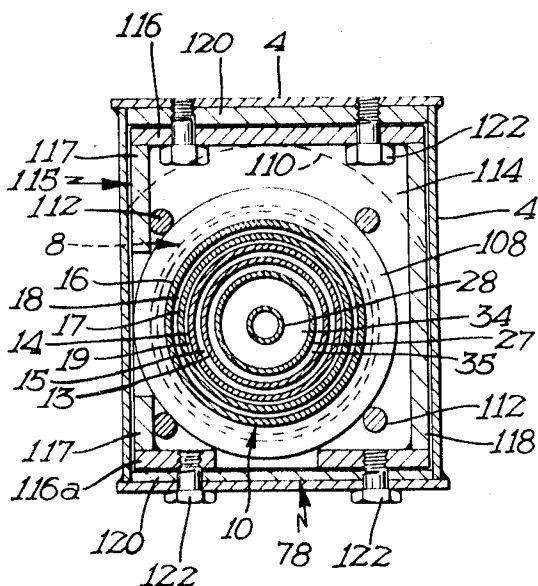


FIG 7



THE 9

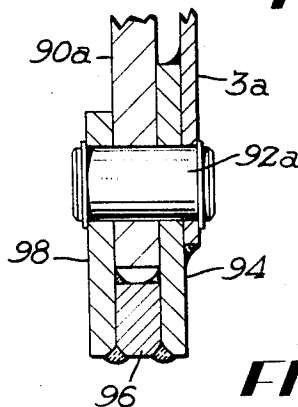


FIG 8

INVENTOR.

DANIEL F. PRZYBYLSKI

BY *Williamson, Palmatier*
& Bains ATTORNEYS

1

3,624,979
TELESCOPING HYDRAULIC CYLINDER ARRANGEMENT FOR MULTIPLE SECTION EXTENSIBLE BOOMS

Daniel F. Przybylski, 636 W. Lake St.,
Winona, Minn. 55987

Filed Aug. 25, 1969, Ser. No. 852,850

Int. Cl. E04h 12/34

U.S. Cl. 52—115

13 Claims

ABSTRACT OF THE DISCLOSURE

A plurality of telescopically arranged hydraulic cylinders having piston surfaces of successively decreasing cross-sectional area are utilized to extend and retract a multiple-section, telescopic structure such as a crane boom. A continuous circuit for the flow of hydraulic fluid to and from the hydraulic cylinders takes the form of interconnected annular passages provided between adjacent, radially spaced wall segments of the hydraulic cylinders. The innermost and smallest diameter hydraulic cylinder is stationary, and the outermost, largest diameter hydraulic cylinder moves outwardly first by hydraulic pressure and carries with it the crane boom section of smallest cross sectional area to which it is connected. Full retraction of the crane boom and hydraulic cylinders to a very compact assembly is provided by connecting each of the successively smaller hydraulic cylinders to a boom section of larger cross sectional area, whereby the smallest, movable hydraulic cylinder is connected at its inner end to the inner end of the boom section of largest cross sectional area.

BACKGROUND OF THE INVENTION

There are numerous applications where hydraulic cylinders are utilized to extend and retract telescopic boom structures, hydraulically actuated crane booms being a prime example. For the great majority of construction jobs, crane booms must have at least three extensible sections in order that they may reach the desired distance and height. This need creates a variety of mechanical problems. In order that a hydraulic crane may have the requisite strength in its various extended positions to handle a desired weight load, each of the boom sections must have a minimum, predetermined cross sectional area to give them the strength required; and thus, a basic design objective must be to avoid excessive and undue reduction in the cross sectional area of successive boom sections with respect to the stationary, largest cross section, base section. This objective becomes particularly difficult to achieve when utilizing the traditional arrangement of separate, independently operable and spaced apart hydraulic cylinders to extend and retract each boom section. The hydraulic cylinders and hoses connected thereto for the flow of hydraulic fluid take up considerable space, thereby substantially reducing the cross sectional space available within each boom section for the housing of a telescoping boom section therein. Moreover, the transverse pin connections normally utilized to connect the piston of each hydraulic cylinder to a boom section structurally interfere with the telescoping disposition of the several boom sections within each other and make it extremely difficult to fully retract the multiple sections of the crane boom. Reference is made to U.S. Pat. No. 3,300,060 for a showing of an example of the commonly used, prior art crane boom incorporating a number of separate, hydraulic cylinders to extend the telescoping boom.

As the number of boom sections is increased, the attendant problems of space, boom section size and cylinder

2

arrangement become more and more difficult to overcome. In fact, where there are more than two extensible boom sections, it is common practice to limit the number of hydraulic cylinders because of the space and weight problems and to operate the outermost or fly boom section manually.

BRIEF SUMMARY OF THE INVENTION

Having in mind the foregoing difficulties and disadvantages associated with presently available hydraulic actuator arrangements for extending multiple section, telescoping structures such as crane booms, I have developed a unique hydraulic cylinder arrangement which requires a minimum of space and which incorporates a plurality of extensible hydraulic cylinders which may be coupled to the several sections of a telescoping crane boom, or similar boom structure, in such a way as to permit the full collapsing of the crane boom in an exceedingly compact assembly requiring only a very nominal reduction in the cross sectional area of the successive boom sections.

These basic objectives are realized by utilizing a telescoping arrangement of several hydraulic cylinders which may be extended and retracted with respect to each other for the purpose of moving boom sections connected thereto, and which include a plurality of annular passages formed within and between the walls of the telescoping cylinders, the several passages being connected in series flow relationship in order to provide a continuous hydraulic circuit.

Preferably, the hydraulic cylinders are assembled with the smallest diameter, innermost cylinder stationary and successively larger diameter hydraulic cylinders slidably disposed in telescoping relation therewith, the largest diameter hydraulic cylinder being disposed at the outermost location and movable first in response to hydraulic pressure because of the fact that its piston head presents the largest cross sectional area on which the fluid pressure is exerted. The succeeding hydraulic cylinders move out in order corresponding to their cross sectional areas.

By virtue of the aforesaid cylinder arrangement, I am able to achieve the particularly desirable goal of extending and retracting a plurality of boom sections of a crane or similar structure in a predetermined, desired sequence providing for maximum strength and support at each extended position. This is accomplished by connecting the outermost boom section of smallest cross sectional area to the largest diameter hydraulic cylinder, which moves outwardly first in response to hydraulic pressure; and successively connecting each larger boom section with the hydraulic cylinder of next smallest diameter, the connecting joints being located at the inner ends of the boom sections and hydraulic cylinders to provide a maximum amount of space within which the successive boom sections may be telescoped and fully collapsed within the boom section of largest cross sectional area. Thus, each succeeding boom section need only be reduced in cross sectional area by an amount to permit it to freely move longitudinally within the larger size boom section within which it is contained.

As a particularly beneficial feature of my improved telescoping boom and cylinder structure, I employ universal joint type of couplings between hydraulic cylinders and the boom sections to which they are attached. This arrangement insures that the loads and bending stresses imposed on the boom sections by the load being lifted by a crane boom will be carried substantially entirely by the strong boom sections and will not be transmitted to the hydraulic cylinders. Thus, no undue stresses will be imposed upon the double-acting hydraulic cylinders and they will move freely in response to fluid pressure to smoothly accomplish the extension and retraction of the crane boom.

3

As a further advantageous feature of my improved boom and cylinder structure, I provide a separate, hydraulic cylinder remotely located from the aforesaid telescoping hydraulic cylinder assembly and connected to an outermost, fly boom section which is movable outwardly with the next larger boom section within which it is telescopically received. This supplementary, separate hydraulic cylinder is connected in fluid flow relation with the annular flow passages provided in the telescoping hydraulic cylinder assembly so as to thereby be connected in the same hydraulic circuit.

These and other objects and advantages of my invention will become readily apparent as the following description is read in conjunction with the accompanying drawings wherein like reference numerals have been used to designate like elements throughout the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are vertical section views showing the inner and outer ends respectively of a multiple section boom incorporating the telescoping hydraulic cylinder arrangement of this invention, the boom and hydraulic cylinders being shown in their fully retracted positions in these views;

FIGS. 3, 4 and 5 are vertical section views showing the inner end, mid-section and outer end of the boom and cylinder assembly in the fully extended position;

FIG. 6 is a vertical section view taken along lines 6—6 at the inner end of the boom assembly;

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

FIG. 8 is a horizontal section view taken along lines 8—8 of FIG. 7; and

FIG. 9 is a vertical section view taken along lines 9—9 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

My unique, telescopically arranged assembly of hydraulic cylinders has been particularly designed for the purpose of extending and retracting multiple section telescoping booms where two or more extensible boom sections are required to achieve the desired extended reach. It will readily be appreciated that there are various types of multiple section, telescoping structures for which there is a need for a relatively compact, simplified hydraulic actuating system. For purposes of illustration, I have shown and described a multiple section boom and telescoping hydraulic cylinder assembly which I consider would be particularly suitable as a telescoping crane boom for construction purposes. Since the general structural configuration of crane booms, and particularly of mobile, telescoping crane units, is well known and forms no part of this invention, I have not shown an entire crane unit, as the manner of adapting my telescoping boom and hydraulic cylinder assembly thereto will be obvious to those skilled in the art. Reference is made to U.S. Pat. No. 3,300,060 for a showing of the type of crane unit for which my improved telescoping boom and hydraulic cylinder assembly is intended to be used.

Referring now to FIGS. 1 and 2, and initially to FIG. 1, I have illustrated a multiple section telescoping boom comprised of a stationary base boom section 1 of largest cross sectional area and outwardly extensible boom sections 2, 3, 4 and 5 of decreasing cross sectional area in the order stated. Stationary boom section 1, which will be the innermost boom section when the boom assembly is fully extended, is rigidly secured at its inner end 1a to a fixed base structure 6 adapted to be mounted on a support platform such as the bed of a mobile crane truck. Normally, base 6 will be pivotally mounted on a horizontal axis so that the boom can be raised and lowered by a hydraulic cylinder in the conventional manner. For the purpose of actuating movable boom sections 2, 3, 4 and 5 for movement in a predetermined sequence between their retracted and extended position, I utilize a plurality

4

of telescopically assembled hydraulic cylinders generally designed by numerals 8, 10 and 12. Innermost and smallest diameter cylinder 12 is comprised of concentric, radially spaced, tubular wall segments 13 and 14 designing therebetween an annular fluid passage 15. In like manner, intermediate hydraulic cylinder 10 has inner and outer tubular wall segments 16 and 17 providing annular flow passage 18 therebetween. Outermost, and largest diameter cylinder 8 is of single walled construction and is radially spaced outwardly from outer wall 16 of cylinder 10 to provide an additional annular flow passage 20. Largest diameter hydraulic cylinder 8 is rigidly secured at its outer end to a transverse closure member in the form of piston head 22. Telescopically received within outer cylinder 8 are successively smaller piston heads 24 and 25 integrally connected to tubular wall segments 16, 17 and 13, 14 of cylinders 10 and 12, respectively, for reciprocal movement therewith. Disposed within innermost hydraulic cylinder 12 is a tubular head 26 to the inner end of which are secured concentric tubes 27 and 28 which alternately serve as inlet and outlet passages for the flow of hydraulic fluid. Smaller diameter fluid tube 28 is connected at its inner end to fitting 30 and externally extending connection tube 31. Tubular segment 32 connects larger diameter flow passage 27 with an external source of hydraulic fluid. Concentric, annular flow passages 34 and 35 are formed between flow tubes 27 and 28 and between tube 27 and inner wall 13 of hydraulic cylinder 12, respectively. Extending lengthwise through piston heads 24 and 25, and through head 26 are a series of longitudinally aligned flow passages 36, 37 and 38, which are in fluid flow communication with tubular conduit 28, and which thereby provides a continuous flow passage leading from inlet tube 31 to the inside of hydraulic cylinder 8. In the collapsed, fully retracted position shown in FIGS. 1 and 2, piston heads 24 and 25, and tubular head 26, are longitudinally spaced apart by slight distances to provide transversely extending openings through which hydraulic fluid may flow from internal passages 36 and 37 to act upon pressure faces 24a and 25a of pistons 24 and 25, respectively.

Each of the heads 24, 25 and 26 is provided with an annular phenolic bearing 40 to permit relative sliding motion between each of the piston heads and the adjacent walls of hydraulic cylinders 8, 10 and 12 against which they bear. Packing rings 41 on heads 24, 25 and 26 on either side of bearing ring 40 serve as seals to contain and restrict hydraulic fluid within the desired flow passages.

In order to provide fluid flow communication through the series of annular flow passages defined as stated above between the concentrically arranged walls of the hydraulic cylinders 8, 10 and 12, a plurality of interconnecting flow ports are located in the tubular flow passage walls as follows. Beginning with outermost annular flow passage 20, and proceeding radially inward, a port 42 in wall 16 of hydraulic cylinder 10 connects annular passages 20 and 18. At the inner end of passage 18 a port 44 in wall 17 of cylinder 10 opens into annular passage 19 defined between walls 14 and 17 of hydraulic cylinders 12 and 10, respectively. Port 48 (FIG. 1) connects the inner end of annular flow passage 15 of hydraulic cylinder 12 with passage 35 which communicates at its outer end through port 50 in tubular wall 27 with primary flow passage 34 leading to and from externally extending conduit 32. The direction of fluid flow through the aforesaid series of annular passages and interconnecting flow ports is described below with respect to the operation of the telescoping hydraulic cylinder assembly. Longitudinally movable hydraulic cylinders 8, 10 and 12 can be made to reciprocate back and forth between extended and retracted positions by the application of hydraulic pressure thereto in a manner hereinafter described. By connecting each of the hydraulic cylinders 8, 10 and 12 to a separate extensible boom section of a multiple section boom assembly, the controlled reciprocal movement of cylinders

5

8, 10 and 12 may be utilized to extend and retract three movable sections 2, 3 and 4 of a 4-section boom assembly, the coupling structure for joining hydraulic cylinders 8, 10 and 12 to boom sections 2, 3 and 4 being described below.

In order to provide even greater boom reach I utilize outer fly boom section 5 and separate, hydraulic cylinder 52 for the actuation thereof. Cylinder 52 is a double-acting hydraulic cylinder having inlet and outlet fittings 53 and 54 for introducing pressurized hydraulic fluid on either side of piston 55 reciprocally contained within cylinder 52. Piston 55 is connected at its outer end to fly boom section 5 by means of tubular connector 56 and pin 57 extending therethrough into a rigid cross strut 58 of boom section 5. Pressurized fluid for extending reciprocal piston 55 from its retracted position of FIGS. 1 and 2 is directed into fitting 53 on cylinder 52 through conduit 60 connected to fitting 62 on the outer end of cylinder 8. Hydraulic fluid is directed through fitting 54 on the outer end of cylinder 52 from annular passage 20 between hydraulic cylinders 8 and 10 by means of a conduit 64 extending between fitting 54 and fitting 66 connected to the inner end of cylinder 8. Hydraulic cylinder 52 is rigidly connected to hydraulic cylinder 8 for movement therewith by means of a mounting bracket 68 connected to extension stud 70 on the inner end of cylinder 52, and by rigid attachment to cylinder slide member 72. Lock nut 74 holds cylinder slide member 72 in secure engagement with threaded stub shaft 76 extending through slide member 72 from the outer end of cylinder 8. Thus, as cylinder 8 moves in and out it carries with it separate hydraulic cylinder 52, and there is no relatively movement between these two cylinders necessitating the use of spring reels for conduits 60 and 64. Indeed, conduits 60 and 64 could be rigid tubing if desired.

Extensible boom sections 2, 3 and 4 are connected at their inner ends to hydraulic cylinders 8, 10 and 12 by a unique coupling arrangement which permits these boom sections to be freely extended in the desired sequence and which provides for their full retraction to the compact storage position shown in FIGS. 1 and 2. Referring now to FIG. 1, it will be seen that largest diameter hydraulic cylinder 8 is connected by coupling means generally indicated by reference numeral 78 to the inner end of boom section 4 which has the smallest cross-sectional area of the movable boom sections except for outer, fly section 5. Intermediate boom section 3 extends rearwardly beyond coupling means 78 and is connected by coupling means 80 to the inner end of hydraulic cylinder 10; and boom section 2 having the largest cross-sectional area of the extensible boom sections is connected by coupling means 82, similar to coupling means 80, to the inner end of smallest diameter hydraulic cylinder 12. There is substantial radial clearance space between large boom section 2 and smallest diameter cylinder 12 to permit the retraction of boom sections 3, 4 and 5 therebetween. It will thus be readily apparent that by coupling the largest movable boom section 2 at its rear or innermost end to the inner end of the smallest hydraulic cylinder 12, and successively coupling the smaller boom sections 3 and 4 to increasingly larger diameter hydraulic cylinders 10 and 8 at their inner ends, the coupling connections 78, 80 and 82 are so located and longitudinally spaced as to present no interference to the substantially full retraction of the successively smaller boom sections 3 and 4 within the larger cross-sectional area of boom section 2. This compact boom assembly providing ample space for the telescoping retraction of the several boom sections within each other is made possible by the telescoping assembly of hydraulic cylinders 8, 10 and 12. These hydraulic cylinders are sufficiently elongated and project rearwardly or inwardly one beyond the other by sufficient distances to permit their connection to boom sections 2, 3 and 4 at the innermost ends of these boom sections in the staggered manner shown, utilizing coupling means 78, 80 and 82. Since outermost and largest diameter hydraulic cylinder 8 will

6

be extended first by the application of hydraulic pressure for reasons hereinafter explained, boom sections 4 and 5 connected thereto will move outwardly and forwardly from larger boom section 3 within which they are received when retracted. Successively smaller diameter hydraulic cylinders 10 and 12 will then move outwardly in that sequence to carry boom sections 3 and 2 outwardly to their fully extended positions.

Coupling means 80 and 82 connecting boom sections 3 and 2 with the inner ends of hydraulic cylinders 10 and 12 are substantially identical, the structure of coupling means 80 being illustrated in FIGS. 6, 7 and 8. Referring now to these three figures, I utilize a yoke number 84 to provide a pivotal connection between the inner end of hydraulic cylinder 10 and a substantially rectangular coupling frame 86. Yoke 84 includes an upright plate 85 which snugly embraces cylinder 10 and which is welded to outer cylinder wall 16. Upper and lower bifurcated connecting portions 87 and 87a projecting rearwardly from plate 85 of yoke 84 embrace top and bottom cross member 88 and 88a of connecting frame 86 and are pivotally attached to rectangular shaped boom section 3 by means of horizontally extending pivot pins 92 and 92a. Side walls 3a of boom section 3 are reinforced at their inner ends by overlying, upright plates 94 which angle rearwardly and downwardly beyond the inner end of boom section 3 in the manner shown in FIG. 7. An L-shaped bracket comprised of base member 96 extending perpendicular to reinforcing plate 94 and V-shaped sidewall segment 98 extending parallel thereto is welded to plate 94 and utilized to receive side legs 90 and 90a of connecting frame 86. As is clearly illustrated with respect to the right side of reinforcing frame 86 and boom section 3 in FIGS. 6 and 8, side leg 90a of frame 86 is received between bracket plate 98 and reinforcing plate 94 and pivotally secured thereto by means of horizontally extending pivot pin 92a. Side leg 90 of frame 86 is connected in the same manner to the other side of boom section 3 by means of pivot pin 92.

By utilizing yoke 84 and connecting frame 86 in the manner shown in combination with the vertically and horizontally extending pivot pins 89, 89a and 92, 92a I have provided a universal joint type of coupling arrangement between hydraulic cylinder 10 and boom segment 3 which insures that no undue stress will be imposed upon hydraulic cylinder 10 by the weight of boom section 3 and a load being lifted. In using the extensible boom structure as a crane boom which is elevated when lifting a load, the load forces acting on boom segment 3 in either a vertical or horizontal direction will be substantially absorbed by the pivotal movement of boom section 3 and/or connecting frame 86 about the horizontal and vertical axes defined by pivot pins 92, 92a and 89, 89a. Thus, hydraulic cylinder 10 will not be subjected to any undue stresses or bending forces transmitted from boom section 3 to which it is connected, and cylinder 10 will be able to reciprocate back and forth freely without binding on the adjacent bearing surfaces on which it slides. The same is true with respect to hydraulic cylinder 12 which is connected to boom section 2 by a substantially identical coupling assembly 82.

With reference to FIGS. 1 and 7, it will be seen that coupling assembly 80 for boom section 10 includes a guide collar 100 within which a phenolic bearing ring 102 is held in place. Collar 100 acts as a cylinder head for cylinder 10 and further contains packing material 104 which is held in place by a cap 106. Bearing ring 102 permits hydraulic cylinder 10 to slide back and forth freely on the outer surface of outer wall 14 of hydraulic cylinder 12.

Each of the other hydraulic cylinders 8 and 12 are provided with similar cylinder heads 101 and 103, respectively, and bearing rings also designated 102, by means of which they are slidably supported. It is to be noted with respect to FIG. 1, that inner hydraulic cylinder 12 is

7

slidably supported on the outside of stationary flow conduit 27 by means of its cylinder head 103 and bearing ring 102. In like manner, cylinder head 101 of outermost hydraulic cylinder 8 is slidably supported on the outer surface of outer tubular wall 6 of intermediate hydraulic cylinder 10.

Coupling means 78 connecting outermost and largest diameter hydraulic cylinder 8 to boom section 4 may be understood most clearly by reference to FIGS. 4 and 9. As may be noted with reference to FIG. 4 wherein boom section 4 and hydraulic cylinder 8 are shown in their fully extended positions, cylinder head and guide collar 101 for cylinder 8 houses a bearing ring 102 which permits the sliding movement of the cylinder head assembly on outer tubular wall 17 of intermediate hydraulic cylinder 10. Seal packing 104 of cylinder head 101 is held in place by cap 108. Welded to the inner end of cylinder 8 is a mounting ring 110 for cylinder head 101. A plurality of circumferentially spaced fasteners 112 located as shown in FIG. 9 secure mounting ring 110 to upright, rectangular plate 114 of coupling frame 115. Coupling frame 115 forms an integral part of the cylinder head assembly and is rigidly attached to cylinder head 101 by welding plate 114 to cylinder head collar 101, plate 114 having a circular aperture which snugly embraces the outer surface of collar 101. Rectangular coupling frame 115 includes top and bottom plates 116 and 116a welded to upright plate 114, and side plates 117 and 118 welded to plates 116 and 116a in the arrangement shown in FIG. 9. Referring again to FIG. 9, it will be seen that boom section 4 has a rectangular cross-section, as do all the boom sections, and is reinforced by top and bottom plates 120 welded to its top and bottom walls at its inner end. Boom section 4 is secured to coupling frame 115 by means of threaded fasteners 122 which extend through the top and bottom plates 116 and 116a of frame 115 into reinforcing plates 120 on boom section 4. I have found that load and strength factors are such as to permit the use of the above-described, relatively rigid coupling means 78 in lieu of the universal joint type of coupling means 80 and 82 for connecting hydraulic cylinder 8 to boom section 4. Since boom section 4 will be the outermost boom section, next to outer, fly section 5 when the boom is fully extended, the bending moment imposed thereon by the load being lifted by the crane boom will be minimal. Thus, the stresses imparted to hydraulic cylinder 8 will not be excessive. Moreover, cylinder 8 is the largest diameter hydraulic cylinder and has ample strength to withstand the load of relatively small boom section 4; and the good support provided for cylinder 8 at its inner and outer ends by coupling means 78 and cylinder slide 72 substantially precludes the possibility of cylinder 8 being deflected under load stress to the extent that it would bind during the extension or retraction thereof.

By virtue of the aforesaid coupling means 78, 80 and 82 connecting boom sections 2, 3 and 4 to reciprocal, double-acting cylinders 8, 10 and 12, boom sections 2, 3 and 4 may be extended and retracted between the positions shown in FIGS. 1, 2 and FIGS. 3, 4 and 5. To facilitate the sliding movement of boom sections 2, 3 and 4 with respect to each other, and to provide adequate support for these boom sections in their extended and retracted positions, they are provided with phenolic wear pads 124, 126 and 128 positioned at their outer ends, intermediate of their lengths, and at their inner ends respectively as shown in FIGS. 1 and 2. For the purpose of limiting the longitudinal movement of the several boom sections with respect to each other, I utilize stop blocks 130 at the outer end of each of the boom sections which are engaged by inwardly positioned blocks 132. When the boom sections are extended outwardly, as is shown in FIGS. 3, 4, and 5, blocks 130 and 132 on adjacent boom sections will be in contact.

In order to extend boom sections 2, 3, 4 and 5 from the fully retracted or collapsed position of FIGS. 1 and

8

2 to the extended positions of FIGS. 3, 4 and 5, pressurized hydraulic fluid is introduced into connecting tube 31 leading to tubular flow conduit 28, and connecting tube 32 is connected to a low pressure zone, such as a fluid reservoir, the control of hydraulic fluid to and from connecting tubes 31 and 32 being regulated by a control valve arrangement not shown. The pressurized hydraulic fluid entering conduit 31 will flow through tubular conduit 28 and aligned flow passages 36, 37 and 38 in piston heads 24, 25 and 26, finally discharging into the outer end of hydraulic cylinder 8 in the manner indicated by the flow arrows in FIGS. 1 and 2. Pressurized fluid will also flow radially outwardly from flow passages 37 and 38, through the transverse spaces between piston heads 24, 25 and 26 into hydraulic cylinders 10 and 12. Hydraulic pressure will thus be exerted on the inside surface of piston head 22 of cylinder 8, as well as on pressure surfaces 24a and 25a of pistons 24 and 25. Since piston head 22 has the greatest cross-sectional area, the pressure acting thereon would produce a greater force than that exerted against pressure faces 24a and 25a of smaller diameter pistons 24 and 25. Thus, cylinder 8 will be forced outwardly first, carrying with it fly boom section 5 to which it is connected by piston 55 and cross strut 58, and boom section 4 to which it is connected by coupling means 78. By virtue of this arrangement, boom sections 4 and 5 initially move outwardly together. Boom section 4 will be pulled outwardly by hydraulic cylinder 8 to the piston shown in FIG. 5 wherein stop block 132 carried thereon will strike outer, stop block 130 on boom section 3 to limit the outer movement of boom section 4. At this time, fly boom section 5 will still be retracted within boom section 4 in the same relative position that these two boom sections occupy with respect to each other in FIGS. 1 and 2. The fluid pressure acting on next largest diameter piston head 24 will then cause hydraulic cylinder 10 connected thereto to slide outwardly, carrying with it boom section 3 to which it is connected by means of coupling means 80. The fully extended position of boom section 3 wherein its limit block 132 has engaged stop block 130 on boom section 2 is shown in FIG. 4. Boom section 2 having the largest cross-sectional area is then extended by the outward movement of piston head 25 and smallest diameter hydraulic cylinder 12 connected thereto. Fluid pressure acting on surface 25a of piston head 25 moves hydraulic cylinder 12 and boom section 2 outwardly to the position shown in FIGS. 3 and 4.

The full extension of the multiple section hydraulic crane boom is completed by the outward movement of outer, fly boom section 5 to the extended position shown in FIG. 5. This is accomplished by the hydraulic pressure acting on the inner face of piston 55 within separate hydraulic cylinder 52. Pressurized fluid is directed into cylinder 52 from hydraulic cylinder 8 through connecting tube 60 which is attached to inlet fitting 53 on cylinder 52. It will thus be seen that the several boom sections are extended outwardly in the desired sequence by reason of the difference in surface areas presented to the hydraulic fluid by pistons 8, 24, 25 and 55. Since piston 55 within separate cylinder 52 has the smallest surface area, the force exerted on it by the hydraulic fluid will be smaller than that acting on any of the other piston heads, thereby insuring that piston 55 and fly boom 5 will be extended last.

As hydraulic cylinders 8, 10 and 12 and piston 55 move outwardly in the aforesaid sequence, the hydraulic fluid contained within annular flow passages 15, 18, 19, 20 and 35 will be forced rearwardly through these flow passages in the circuitous path indicated by the flow arrows in FIGS. 1 and 2. This fluid will eventually enter annular flow passage 54 between tubular conduits 27 and 28 through port 50 and will be discharged through connecting tube 32 to a low pressure zone in the form of a fluid reservoir. The expulsion of the hydraulic fluid in the aforesaid annular passages during hydraulic cylinder extension is caused by the force exerted on the fluid by

cylinder heads 100, 101 and 103 as they move outwardly from left to right towards one of the momentarily stationary piston heads 24, 25 or 26. For example, as cylinder 8 moves outwardly the hydraulic fluid contained within annular passage 20 will be forced by cylinder head 101 towards piston head 24 which is still stationary at this time. The fluid contained within annular passage 20 is forced therefrom through port 42 into annular passage 18. The inward and rearward movement of hydraulic fluid through annular passages 15, 18, 19 and 35 by way of interconnecting flow ports 42, 44, 46 and 48 continues as cylinder heads 80 and 82 are sequentially extended with hydraulic cylinders 10 and 12. The fluid contained on the right side of piston 55 within hydraulic cylinder 52 is expelled through fitting 60 and conduit 64 into annular passage 20 from which it flows rearwardly into annular fluid passage 34 and out connecting tube 32 in the aforesaid manner.

The retraction of boom sections 2, 3, 4 and 5 in the precise reverse order from that in which they are extended is accomplished by introducing pressurized fluid into tube 32 and connecting inlet tube 31 to the low pressure zone (fluid reservoir). As may be noted with reference to FIGS. 3, 4, and 5, pressurized fluid entering tubular connection 32 will flow outwardly and forwardly through annular passage 34 and connecting flow ports 50 and 48 into annular passage 15 formed between tubular wall segments 13 and 14 of hydraulic cylinder 12. Pressurized fluid flow will continue outwardly through annular flow passages 15 and 18 of hydraulic cylinders 10 and 12 by means of interconnecting flow ports 44 and 46, the fluid ultimately reaching annular passage 20 between hydraulic cylinders 8 and 10. From passage 20, pressurized fluid will flow through conduit 64 to the outer end of supplemental cylinder 52 to act on the outer, piston head surface 55a of piston 55. The telescoping hydraulic cylinders and boom sections connected thereto are returned to their fully retracted positions of FIGS. 1 and 2 by the fluid pressure acting on annular pressure surfaces 103a, 100a and 101a of cylinder heads 103, 100 and 101 respectively. The pressure acting on the outer face of piston head 55a serves to retract piston 55. The differential in cross sectional area between pressure surfaces 103a, 100a, 101a and 55a, and the ratios of each of these surfaces to their respective opposing pressure surfaces 25a, 24a, 22 and 55b causes piston 55 and the hydraulic cylinders to retract in the sequence 55, 12, 10, and 8 to return boom sections 5, 2, 3 and 4 to their retracted positions in that order. In considering the fluid dynamics effecting the retraction of the hydraulic cylinders, it is to be noted initially that in their extended positions, cylinders 8, 10 and 12 and 52 are filled with hydraulic fluid which acts on piston head surfaces 22, 24a, 25a and 55b of these cylinders to resist their retracting movement. The opposing force of fluid in cylinder 52 acting on face 55b of piston 55 is relatively small because of the small difference between the surface areas 55a and 55b in comparison to the relatively large difference in effective area between each of the cylinder head surfaces 103a, 100a and 101a and their respective opposing pressure surfaces 25a, 24a and 22 on pistons 12, 10 and 8. For example, pressure area 101a on which pressurized fluid in annular passage 20 acts to retract cylinder 8 is very small in comparison to the large surface area of piston head 22 of cylinder 8. Thus, there will be much greater resistance to the return movement of cylinder 8 due to the force of the fluid therein acting on piston head 22 than there will be to the retracting movement of piston 55. The same is true with respect to the other telescoping cylinders 10 and 12.

Piston 55 will therefore be retracted first and carry fly boom section 5 inwardly into telescoping relation with boom section 4. Cylinders 12, 10 and 8 will then retract in sequence, thereby returning boom sections 2, 3,

and 4 to their retracted positions in that order. As boom section 2 is retracted, it carries boom sections 3 and 4 in with it by reason of the engagement of stop blocks 130 with blocks 132 on the successively smaller boom sections. In like manner boom section 3 carries boom section 4 inwardly.

As the cylinders are retracted, the inward or rearward movement of piston heads 55, 22, 24 and 25 forces the hydraulic fluid contained within cylinders 52, 8, 10 and 12 rearwardly through piston head passages 36, 37 and 38 into flow tube 28 and out connecting tube 31 to the fluid reservoir.

Based on the foregoing description, it will readily be appreciated by those skilled in the art that my particular, telescoping arrangement of hydraulic cylinders having pressure surfaces predetermined area differentials and coupled to extensible boom sections at their inner ends in the aforesaid manner permits me to provide a very compact boom structure of minimum overall size and weight while insuring the retraction and extension of the boom sections in the desired sequence. Minimal bending stresses are imposed on the hydraulic cylinders because of the support given to the cylinders at their opposite ends utilizing slidably supported piston heads 22, 24 and 25 and cylinder head coupling means 78, 80 and 82. It is to be noted that the pistons between support points for the movable hydraulic cylinders 8, 10 and 12 is substantially less than that which could be provided if cylinders having extensible pistons were utilized in the conventional manner to actuate the boom sections. The distance between the outer end of a fully extended piston and the base end of a hydraulic cylinder within which it is reciprocally mounted would be approximately twice as great as the distance between the piston heads and cylinder heads for each of the hydraulic cylinders 8, 10 and 12.

It is to be understood that various numbers of telescoping hydraulic cylinders and extensible boom sections may be used. A five section boom has been shown and described for illustrative purposes only. If a lesser number of boom sections is desired, I prefer to eliminate one or more of the intermediate boom sections 2, 3 and 4 and to retain fly boom section 5 and the separate, hydraulic cylinder 52 by means of which it is extended and retracted with respect to the other boom sections. The reason for this is that particular advantages are achieved by connecting fly boom section 5 to largest diameter hydraulic cylinder 8 for initial movement of boom sections 4 and 5 together, cylinder 8 being connected to boom section 4 at its inner end by coupling means 78 as described above. By initially extending two boom sections together by means of one telescopically assembled hydraulic cylinder, sufficient boom strength is provided to elevate a load then being carried on a crane boom within imposing excessive boom weight on the hydraulic extension cylinders as would be the case if a single, larger diameter boom were extended outwardly first. The provision of a separate hydraulic cylinder as is shown in 52 having a predetermined piston area relative to that of the telescopically assembled hydraulic cylinder(s) insures that the outermost fly boom section will be extended last and retracted first to minimize the load force imposed thereon. For example, it would be highly undesirable to extend the fly boom section first with a load being carried on a crane boom because the small, relatively light fly boom section would not have sufficient strength to properly lift and support the load. By way of example, if only a three section boom were desired, then intermediate boom sections 2 and 3 would be eliminated and boom sections 4 and 5 would be telescopically mounted within a larger, stationary boom section, such as base section 1. A single, reciprocally movable hydraulic cylinder as shown at 8 would be connected to boom sections 4 and 5 at its opposite ends in the manner described and illustrated herein to initially extend the two boom sections together. A separate, hy-

11

draulic cylinder having a piston reciprocally mounted therein, of the type shown at 52, would be used in combination with the first hydraulic cylinder to extend and retract fly boom section 5 relative to larger diameter boom section 4. In such a case, the single, reciprocally movable hydraulic cylinder would be telescopically arranged for sliding support on a tubular member contained therein, such as that shown at 27 in FIGS. 1 and 2. There may, of course, also be circumstances where the fly boom section and separate hydraulic cylinder 52 therefor are not desired or required, in which event only a plurality of telescopically arranged hydraulic cylinders as shown at 8, 10 and 12 would then be used to extend and retract the several boom sections.

What is claimed is:

1. In combination with a multiple section, extensible boom having a plurality of tubular boom sections telescopically retractable and extensible with respect to each other and housed within a stationary base section, a hydraulic cylinder arrangement for extending and retracting said boom sections comprising:

a plurality of telescopically assembled hydraulic cylinders having their longitudinal axes coextensive with the longitudinal axis of said extensible boom, said cylinders being contained within said extensible boom and reciprocally movable with respect to each other along their longitudinal axes;

a piston head at one end of each of said cylinders serving as a first pressure surface therefor and a second pressure surface on each of said cylinders;

first and second fluid passage means for alternately introducing pressurized fluid to either said first or second pressure surfaces respectively to alternatively extend and retract said hydraulic cylinders; and

a plurality of coupling means extending transversely of said extensible boom and connecting each of said hydraulic cylinders to one of said extensible boom sections for the reciprocal movement thereof, the largest diameter cylinder being connected to the smallest cross sectional area boom section, which is also the outermost boom section along the length of said boom with respect to said base section, and the successively smaller cylinders being connected to successively larger and more inwardly disposed boom sections with the smallest diameter cylinder being connected to the largest, and innermost, extensible boom section, and all of said coupling means being located at the inner ends of said cylinders to avoid interference with said plurality of boom sections and to permit said boom sections to be fully retracted to a compact storage position adjacent said stationary base section.

2. An extensible boom and hydraulic cylinder arrangement as defined in claim 1 wherein:

the largest diameter hydraulic cylinder is the most outwardly positioned cylinder along the longitudinal axis of said extensible boom and the smallest diameter cylinder is positioned most inwardly adjacent to said base boom section; and

said first and second pressure surfaces on said hydraulic cylinders have effective areas bearing predetermined ratios to each other such that upon the application of pressurized fluid to said pressure surfaces said largest cylinder and smallest boom section connected thereto will extend first and be retracted last, and said smallest cylinder and largest boom section connected thereto will extend last and be retracted first.

3. An extensible boom and hydraulic cylinder arrangement as defined in claim 1 wherein:

said piston heads of each of said hydraulic cylinders having smaller diameters than the largest one of said cylinders are located at the outer end of each of said cylinders and are supported for relative sliding move-

12

ment on the next larger diameter cylinder within which they are telescopically received; and each of said coupling means is slidably supported on the outside surface of the next smaller diameter hydraulic cylinder immediately adjacent to the cylinder to which each coupling means is connected, whereby each of said hydraulic cylinders is supported at its opposite ends by said coupling means and piston heads to thereby preclude the imposition of undue bending loads on said cylinders from said boom sections.

4. An extensible boom and hydraulic cylinder arrangement as defined in claim 3 wherein:

said largest diameter cylinder is supported at its outer end on the boom section within which it is contained in such a way as to permit relative sliding movement therebetween; and

said couplings for at least the largest and heaviest ones of said boom sections are universal joints permitting relative pivotal movement between said largest boom sections, and the cylinders to which they are connected about horizontal and vertical axes.

5. An extensible boom and hydraulic cylinder arrangement as defined in claim 1 wherein:

said piston heads are located at the outer ends of each of said cylinders and said largest extensible boom section is spaced outwardly from said smallest cylinder by a substantial distance to provide a relatively large, annular clearance space therebetween within which the successively smaller boom sections are telescopically received; and

each of said successively smaller cylinders extends rearwardly from its piston head beyond the inner end of the next larger diameter cylinder within which it is received, whereby said coupling means at the inner ends of said cylinders will be longitudinally spaced apart from each other along the length of said extensible boom when said cylinders are retracted.

6. An extensible boom and hydraulic cylinder arrangement as defined in claim 1 wherein:

said extensible boom further includes an outer, fly boom section movable along its longitudinal axis and telescopically received within the outermost one of said plurality of extensible boom sections;

an additional hydraulic cylinder separate from said telescopically assembled hydraulic cylinders having a piston reciprocally movable therein, said piston being connected to said fly boom section for the extension and retraction thereof;

fluid conduit means separately communicating the opposite ends of said additional hydraulic cylinder with said first and second fluid passage means; and means connecting said fly boom section to said largest diameter hydraulic cylinder for movement therewith, whereby both said fly boom section and said outermost one of said plurality of boom sections within which said fly boom section is contained will be simultaneously extended and retracted by the reciprocating movement of said largest diameter hydraulic cylinder.

7. An extensible boom and hydraulic cylinder arrangement as defined in claim 1 wherein:

said first fluid passage means comprises a tube extending longitudinally within said hydraulic cylinders and space inwardly therefrom and a series of aligned apertures extending longitudinally through said piston heads in fluid flow communication with said tube and the inside of said cylinders and said piston heads, said tube being connected at the inner end of said base boom section with an external fluid supply system; and

said second fluid passage means comprises a plurality of series connected annular passages formed within and between the walls of said hydraulic cylinders and extending longitudinally thereof, at least the inner-

13

most and smaller diameter hydraulic cylinders having inner and outer, radially spaced, tubular walls defining certain ones of said annular flow passages therebetween, said annular passages being in fluid flow communication with said external fluid supply system by means of a flow connection at the inner end of said base boom section.

8. An extensible boom and hydraulic cylinder arrangement as defined in claim 1 wherein:

said second pressure surface on each of said cylinders is in the form of an annular surface defined by a cylinder head attached to each of said cylinders at the ends thereof opposite said piston heads, said annular cylinder head pressure surfaces being in fluid flow communication with said second fluid passage means; and

said cylinder heads being secured to said coupling means.

9. A fluid pressure actuated extensible boom comprising:

a plurality of reciprocally movable, tubular, boom sections telescopically retractable into a compact boom assembly;

a plurality of telescoping hydraulic cylinders extending longitudinally within said boom assembly, said cylinders being of successively decreasing diameter and having integral piston heads at one end thereof by means of which each of the smaller diameter cylinders is supported for relative sliding movement on the next larger diameter cylinder within which it is contained;

opposing pressure surfaces on each of said cylinders by means of which said cylinders may be reciprocated by the application of pressurized fluid thereto; and a cylinder head coupling connecting the opposite end of each of said cylinders with one of said boom sections, each of said couplings being slidably supported on the outside surface of the next smaller diameter hydraulic cylinder disposed radially inwardly from the cylinder to which each coupling is connected.

10. An extensible boom as defined in claim 9 wherein:

each of said cylinder head couplings has an annular surface area thereon forming one of said opposing pressure surfaces.

11. A telescoping multiple section boom and hydraulic actuating assembly comprising:

a first, stationary, base boom section; at least one intermediate boom section movable along its longitudinal axis and telescopically contained within said base boom section;

an outer, fly boom section movable along its longitudinal axis in telescoping relation with said base boom and said intermediate boom sections;

a first hydraulic cylinder reciprocally movable along its longitudinal axis and telescopically arranged in surrounding relation with respect to a stationary, smaller diameter tubular member contained therein;

14

opposed pressure surfaces on said hydraulic cylinder; two, separate fluid passage means in fluid flow communication with said pressure surfaces for alternately conducting pressurized fluid thereto to extend and retract said first hydraulic cylinder, said fluid passage means being in the form of non-flexible passages extending longitudinally of said first hydraulic cylinder and defined by the walls of said cylinder and said stationary tubular member;

a second, double-acting hydraulic cylinder having a piston reciprocally movable therein, said piston being connected to said fly boom section;

fluid conduit means separately communicating the opposite ends of said second hydraulic cylinder with said two, separate, fluid passage means; and

coupling means connecting the inner end of said first hydraulic cylinder with the inner end of said intermediate boom section, said intermediate boom section being spaced outwardly from said first hydraulic cylinder to define therewith an annular space within which said fly boom section is telescopically received.

12. A telescoping multiple section boom and hydraulic actuating assembly as defined in claim 11 wherein:

the opposed, effective surfaces areas of said piston and said opposed pressure surfaces on said first hydraulic cylinder are of a predetermined ratio effective to extend said first hydraulic cylinder first and to retract said piston first in response to the application of pressurized fluid thereto.

13. A telescoping multiple section boom and hydraulic actuating assembly as defined in claim 11 wherein:

said second, double-acting hydraulic cylinder is contained within said fly boom section and is mounted on said first hydraulic cylinder for movement therewith; and

said fluid conduit means comprises first and second fluid lines extending between the opposite ends of said first and second hydraulic cylinders.

References Cited

UNITED STATES PATENTS

2,517,153	12/1950	Wood	92—53
2,670,811	7/1954	Shafer	92—53
2,715,954	9/1955	Rowan	52—115
2,787,383	4/1957	Antos	212—55
3,128,674	4/1964	Ganchar	91—167
3,212,604	11/1965	Garnett	212—55
3,270,899	10/1966	Brown	212—55
3,276,549	1/1966	Ramsey	92—51
3,353,686	12/1967	Cowan	212—55
3,398,492	9/1968	Nansel	52—115

HENRY C. SUTHERLAND, Primary Examiner

U.S. Cl. X.R.

52—118; 212—55