United States Patent [19]

Sakamoto et al.

[11] **3,722,154**

[45] **Mar. 27, 1973**

[54] **EXTENSIBLE BOOM WITH BUCKLING-PREVENTION**

[76] Inventors: **Teruya Sakamoto,** 2482-10 Midori-cho, Sakaide; **Takemi Nishimura,** 230-14 Nonowe, Havikino; **Osamu Takarada,** 1475 Omachi, Mure-cho, Kita-Gun, all of Japan

[22] Filed: **Oct. 15, 1970**

[21] Appl. No.: **80,913**

[30] **Foreign Application Priority Data**

Jan. 31, 1970 Japan 45/8718
Feb. 2, 1970 Japan 45/9452

[52] **U.S. Cl.** **52/121,** 52/115, 212/55
[51] **Int. Cl.** **E04h 12/34**
[58] **Field of Search** ..52/111, 112, 121, 115; 212/55; 92/117, 126, 137, 165

[56] **References Cited**

UNITED STATES PATENTS

1,751,348	3/1930	Mitchell	52/121
1,244,784	10/1917	Schilder	92/137
2,645,213	7/1953	Huber	92/126
3,431,825	3/1969	Crawley et al.	92/165 R
3,464,169	9/1969	Potain	52/115

FOREIGN PATENTS OR APPLICATIONS

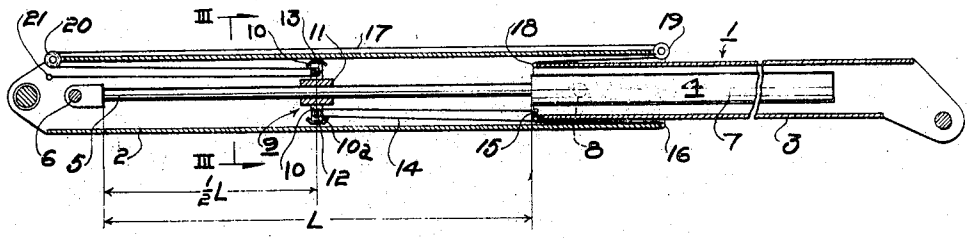
1,217,041	3/1966	Germany	212/55
1,268,804	3/1968	Germany	212/55
996,853	6/1965	Great Britain	212/55

Primary Examiner—Frank L. Abbott
Assistant Examiner—Leslie A. Braun
Attorney—Olson, Trexler, Wolters & Bushnell

[57] **ABSTRACT**

In an extensible boom of the type having telescopically extensible boom members, a buckling-preventing method for hydraulic cylinder unit employed in the boom wherein an intermediate position of an optionally extended piston-rod of said cylinder unit is always supported with a buckling-preventing device having legs slidably or rotatably engaged with inner circumference of a boom member. The present invention further includes driving means for said buckling-preventing device which moves the device to said intermediate position of the piston-rod in connection with the operation of said cylinder unit.

11 Claims, 28 Drawing Figures



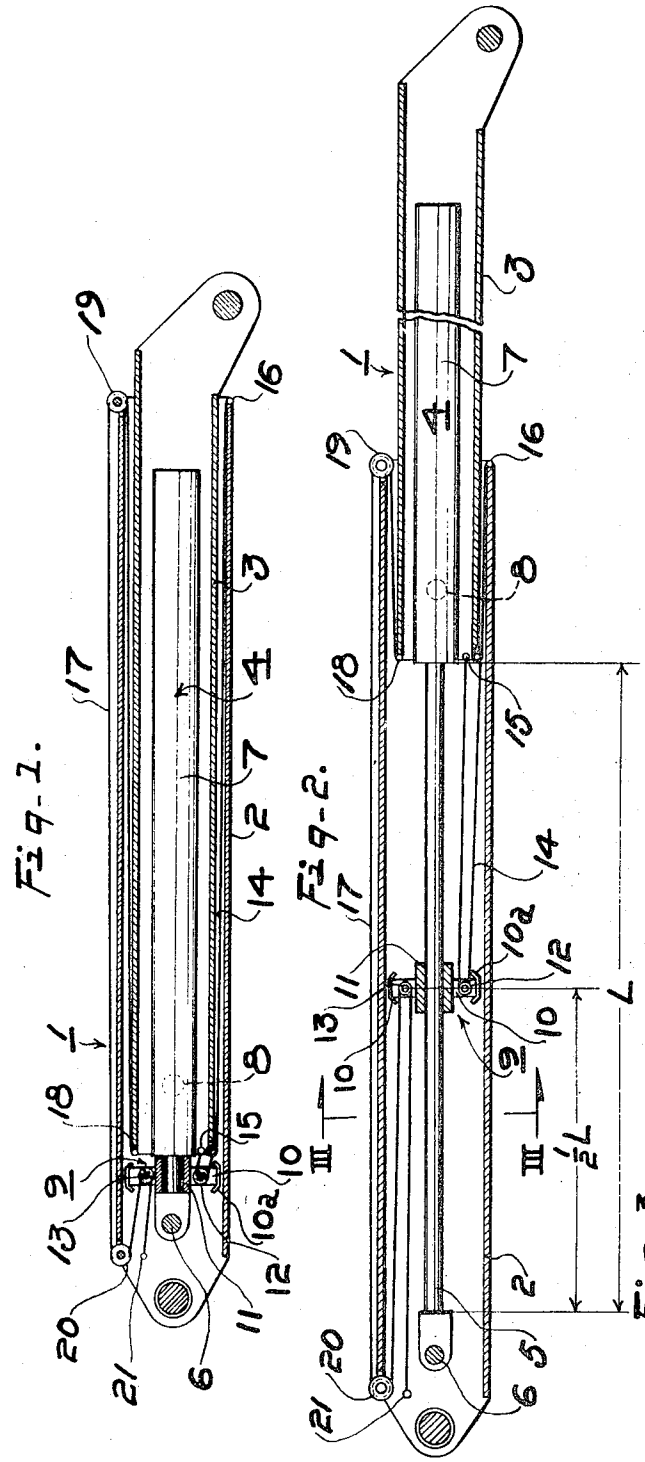


Fig-1.

Fig-2.

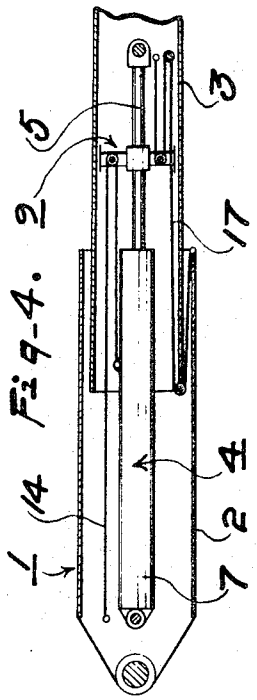


Fig-4.

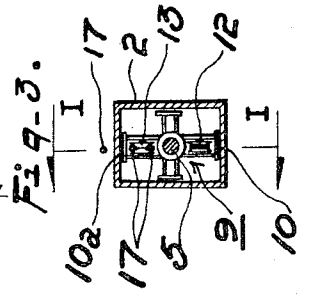


Fig-3.

INVENTORS

Takemi Nishimura
Teruya Sakamoto
Osamu Takarada

By: Olson, Trexler, Wolters & Bushnell ATTORNEYS

Fig-5.

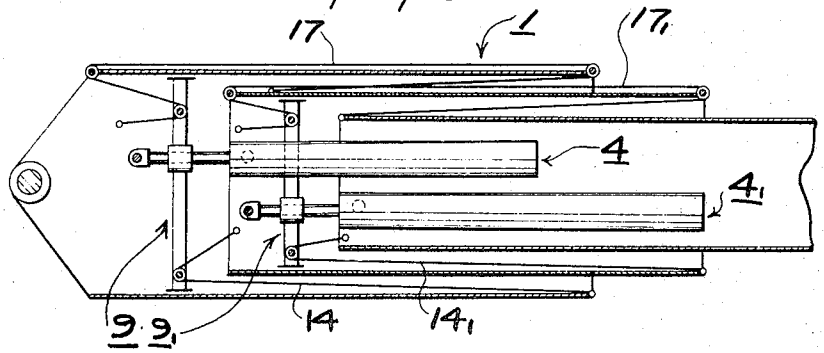


Fig-6.

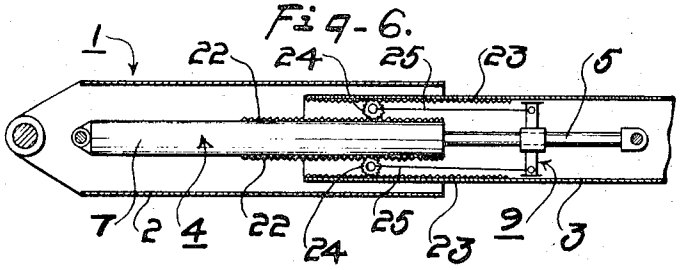


Fig-7.

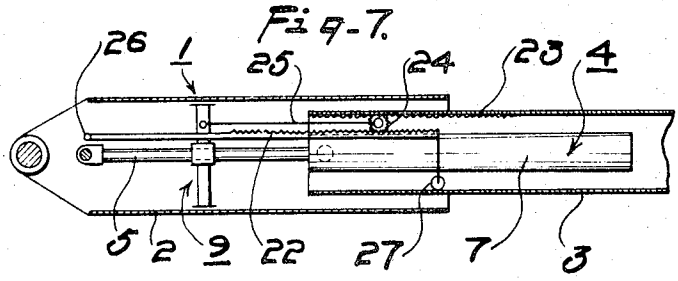
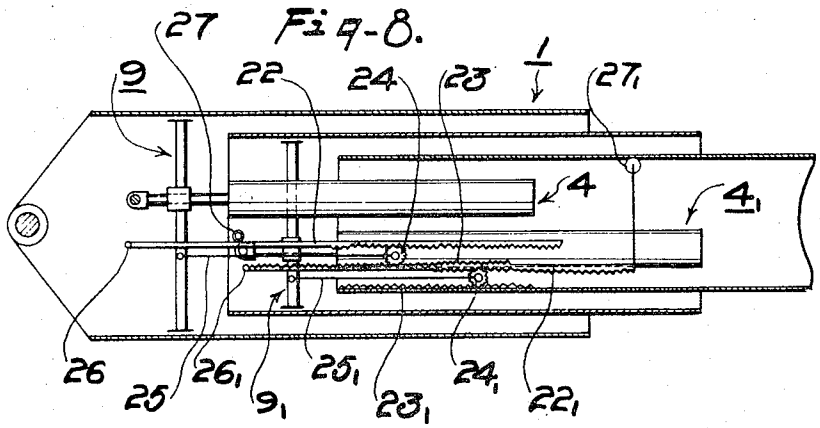
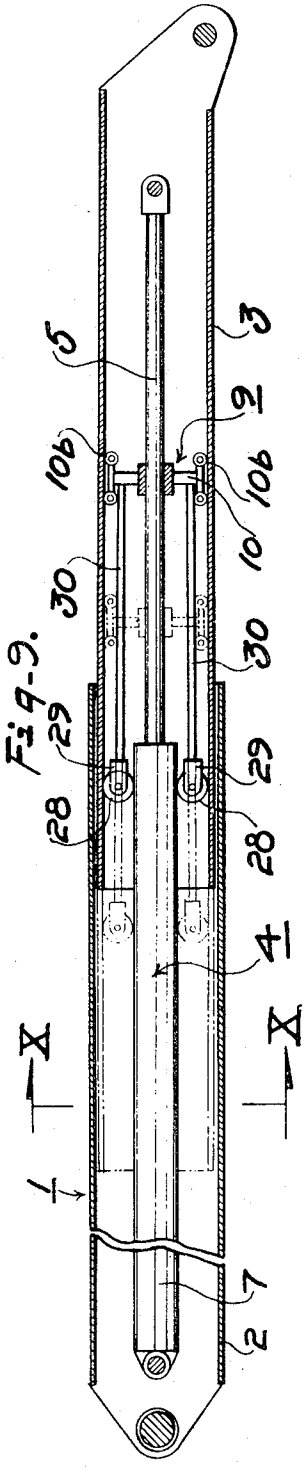
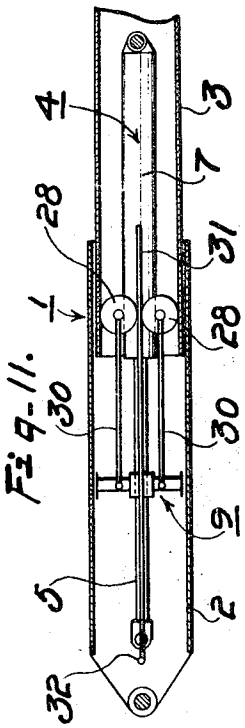


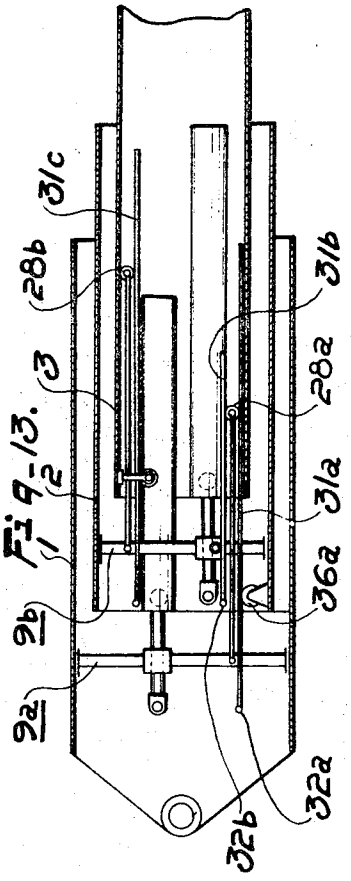
Fig-8.

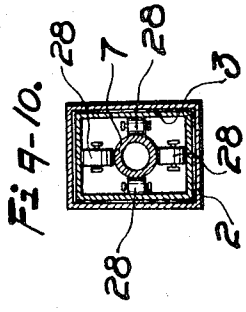


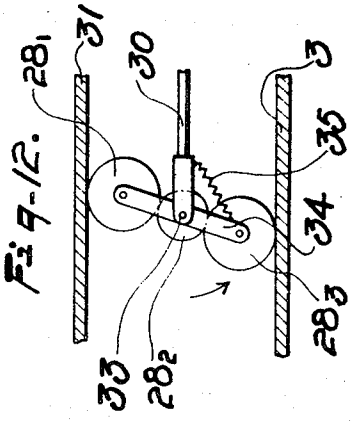
INVENTORS
Takemi Nishimura
Teruya Sakamoto
Osamu Takarada
BY
Olson, Trexler, Wolters & Bushnell ATTORNEYS











INVENTORS

Takemi Nishimura
Teruya Sakamoto
Osamu Takarada

BY

Olson, Trexler, Wolters & Bushnell ATTORNEYS

Fig 9-14.

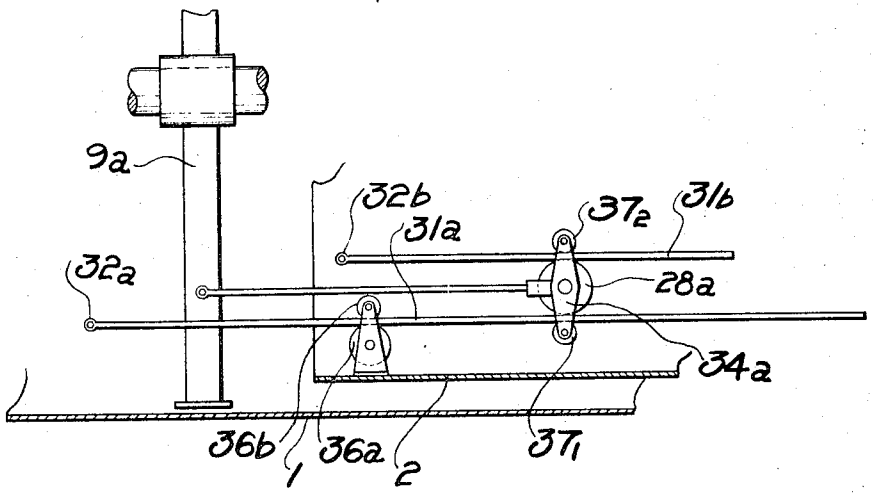


Fig 9-15.

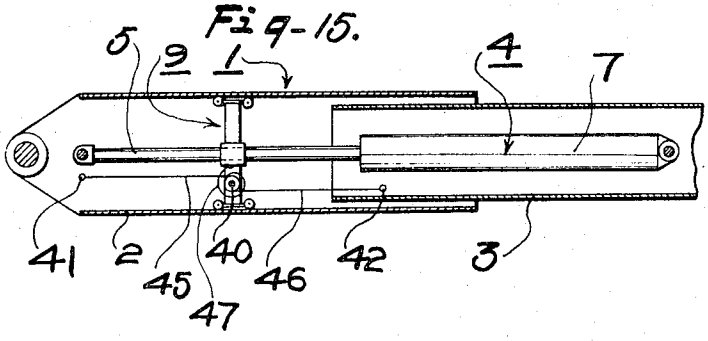


Fig 9-16.

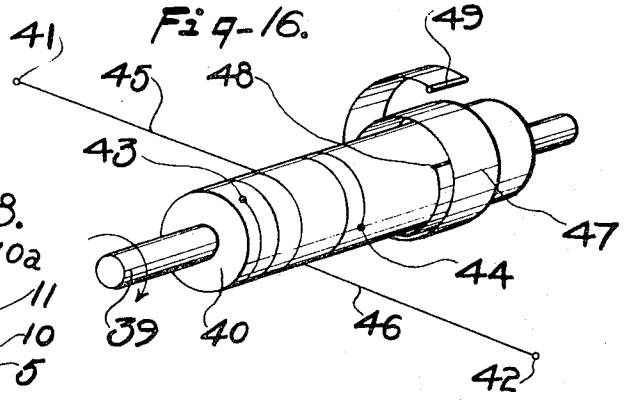
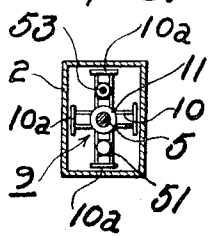
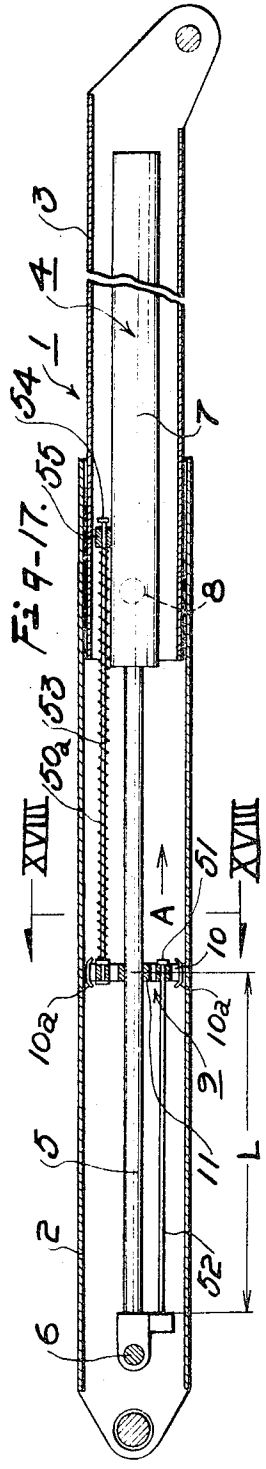


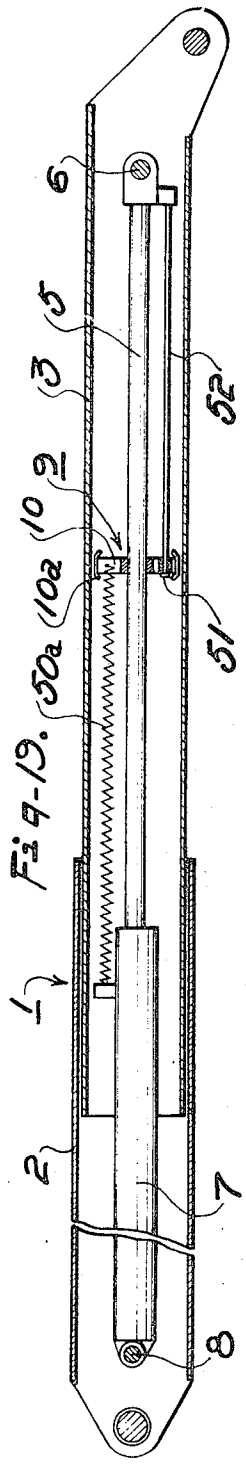
Fig 9-18.

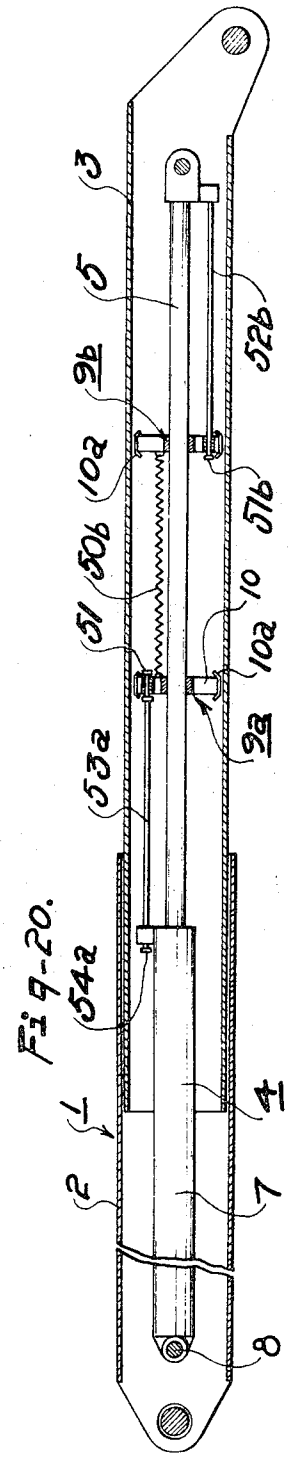


INVENTORS
Takemi Nishimura
Teruya Sakamoto
Osamu Takarada

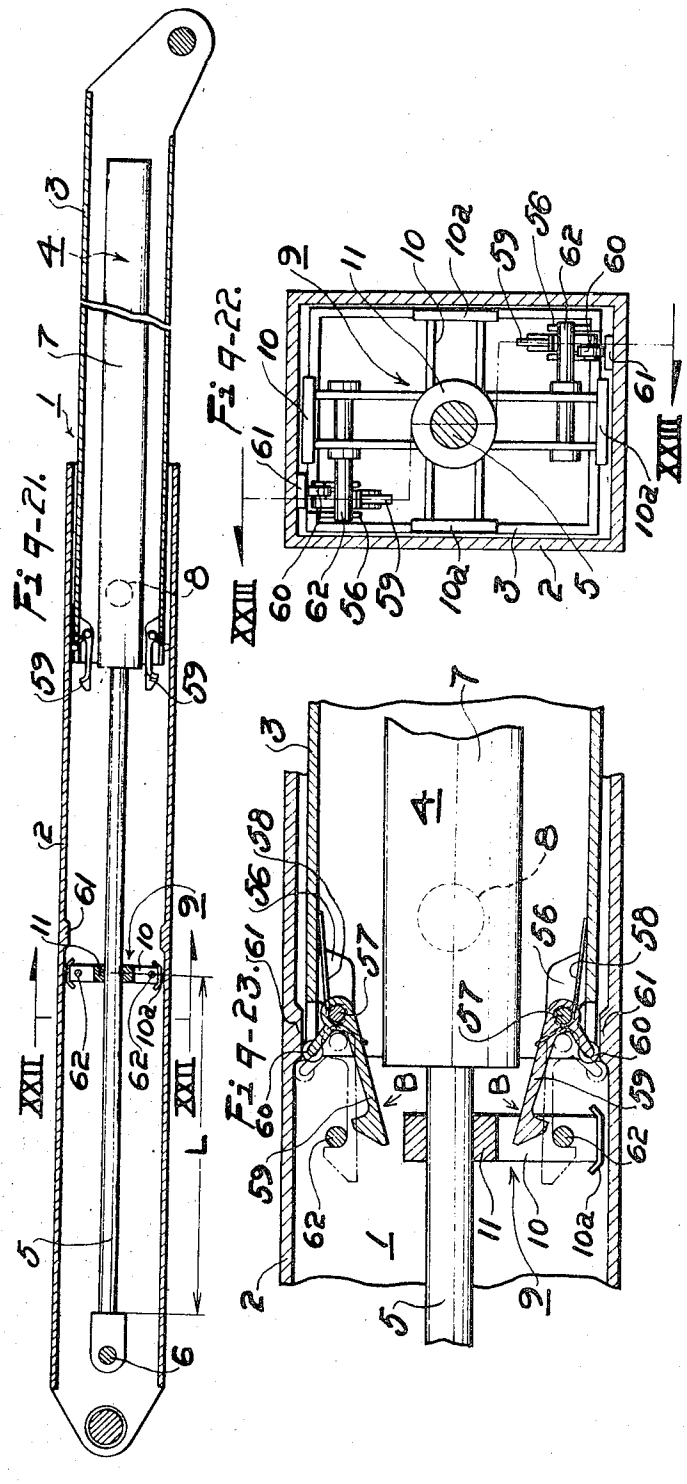
BY
Olson, Trexler, Wolters & Bushnell ATTORNEYS







INVENTORS
Takemi Nishimura
Teruya Sakamoto
Osamu Takarada
BY
Olson, Trexler, Wolters & Bushnell
ATTORNEYS.



INVENTORS
Takemi Nishimura
Teruya Sakamoto
Osamu Takarada
BY
Olson, Trexler, Wolters & Bushnell
ATTORNEYS.

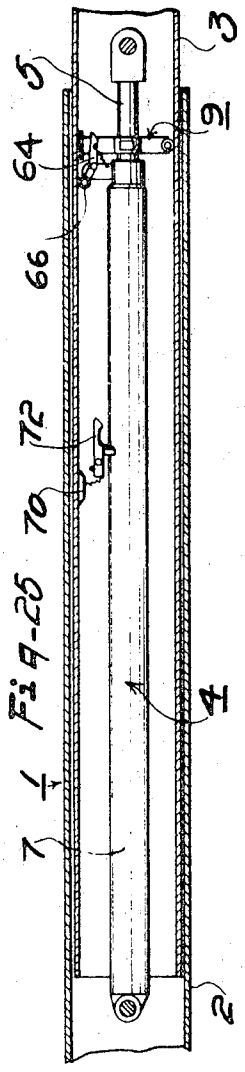


Fig-25

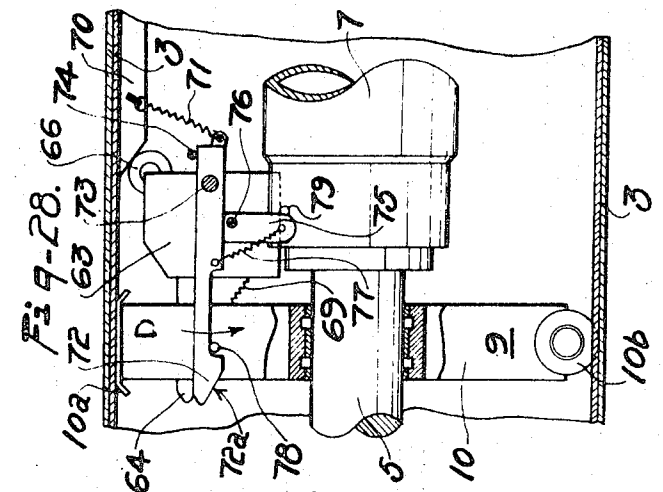


Fig-28.

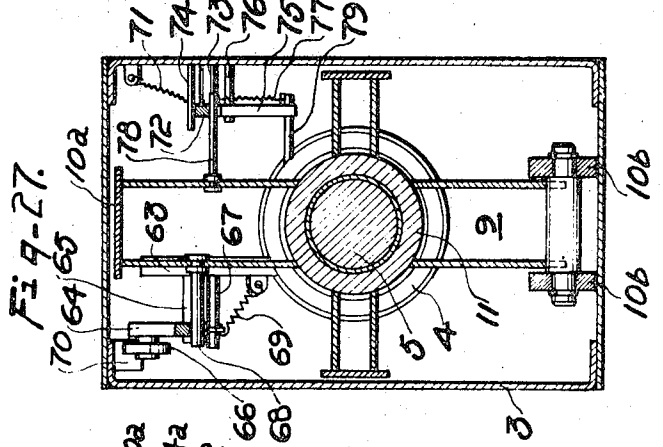


Fig-27.

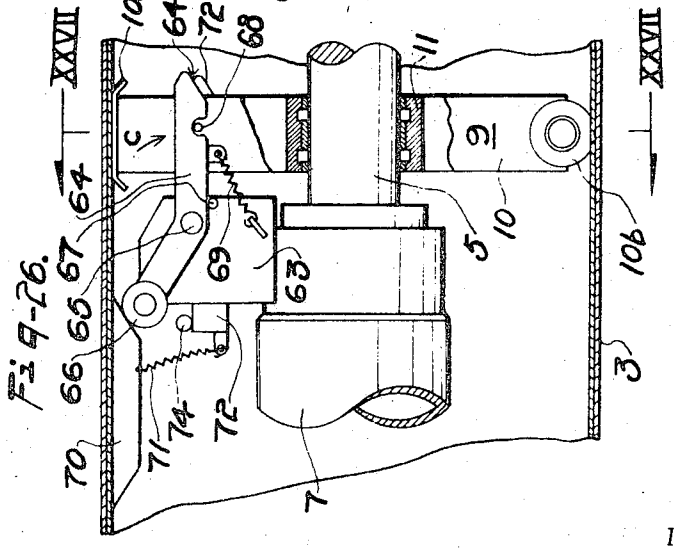


Fig-26.

INVENTORS
Takemi Nishimura
Teruya Sakamoto
Osamu Takarada
BY
Olson, Trexler, Wolters & Bushnell
ATTORNEYS

EXTENSIBLE BOOM WITH BUCKLING-PREVENTION

SUMMARY OF THE INVENTION

This invention relates to an extensible boom of the type having telescopically extensible boom members, and more particularly to a buckling-preventing method for hydraulic cylinder unit employed in the boom of the aforementioned type and an apparatus therefor.

DISTINCTIONS OVER THE PRIOR ART AND OBJECTS

In an extensible boom for a crane comprising an inner boom member telescopically inserted into an outer boom member, there is arranged a hydraulic cylinder unit for extending and contracting the boom. That is, in the extensible boom, the piston-rod of said cylinder unit is connected at the free end thereof to the outer or inner boom member, and the cylinder of said unit is connected at a suitable portion thereof to the other boom member, so that the extensible boom is extended or contracted as the hydraulic cylinder unit is extended or contracted. A compressive stress applied to the extensible boom is supported by the hydraulic cylinder unit, so that extremely high compressive stress is applied to the unit during loading and unloading works with a crane.

When the extensible boom or the hydraulic cylinder unit is extended, the resistivity against buckling of the cylinder unit, especially the piston-rod of said unit, namely the resistivity against the braking due to buckling stress applied to the extended piston-rod, is decreased with the increase in extension of the boom, and more exactly of the span of extended piston-rod determined with the length of each boom member. In other words, the longer the span is, the higher resistivity against buckling is required.

On the other hand, a crane with a high lift is required recently, so that each boom member of an extensible boom for a crane becomes very long whereby a longer piston-rod of a hydraulic cylinder unit becomes required for extending and contracting such a long boom member.

When the span of an extended piston-rod becomes longer, a piston-rod with a larger diameter is usually used for giving a required strength against buckling to the same. However, when the diameter of the piston-rod is increased, then the hydraulic cylinder unit becomes large-scaled and is increased in weight and in cost. There have never been proposed methods or apparatus for avoiding these defects.

Accordingly, the primary object of the present invention is to provide a novel buckling-preventing method for hydraulic cylinder unit employed in an extensible boom by which above defects are fully avoided and which guarantees the exclusion of the bending of extended piston-rod due to buckling stress applied to the rod.

Another object of the present invention is to provide a buckling-preventing method for hydraulic cylinder unit which utilizes boom members skillfully so as to achieve the primary object in a simple manner.

The above objects are attained according to the present invention by providing a buckling-preventing device which comprises a portion slidably received with the piston-rod and legs slidably or rotatably engaged with the inner circumference of the boom, and by moving said device into a predetermined intermediate position between the free end of the piston-rod and the end of the cylinder in connection with the extending and contracting operation of hydraulic cylinder unit.

The present invention further aims at the provision of driving method and means for the aforementioned buckling-preventing device which allow to move the device into said predetermined position in a desirable manner.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention and its advantages will become more readily apparent as the specification is considered in conjunction with the accompanying drawings in which:

FIG. **1** is a sectional side view of an embodiment of two-stage extensible boom according to the present invention showing a contracted state and taken along line **1—1** of FIG. **3**;

FIG. **2** is a sectional side view of the extensible boom shown in FIG. **1** showing an extended state;

FIG. **3** is a sectional view taken along line **3—3** of FIG. **2**;

FIG. **4** is a sectional side view of another embodiment of a two-stage extensible boom according to the present invention;

FIG. **5** is a sectional side view of still another embodiment of a three-stage extensible boom according to the present invention;

FIG. **6** is a sectional side view of a further embodiment of a two-stage extensible boom according to the present invention;

FIG. **7** is a sectional side view of a still further embodiment of a two-stage extensible boom according to the present invention;

FIG. **8** is a sectional side view of another embodiment of a three-stage extensible boom according to the present invention;

FIG. **9** is a sectional side view of still another embodiment of a two-stage extensible boom according to the present invention;

FIG. **10** is a sectional view taken along line **10—10** of FIG. **9**;

FIG. **11** is a sectional side view of a further embodiment of a two-stage extensible boom according to the present invention;

FIG. **12** is a side view of another embodiment of employed rollers according to the present invention;

FIG. **13** is a still further embodiment of a three-stage extensible boom according to the present invention;

FIG. **14** is a side view showing the relation between plate members and rollers;

FIG. **15** is a sectional side view of another embodiment of a two-stage extensible boom according to the present invention;

FIG. **16** is an enlarged perspective view of the drum shown in FIG. **15**;

FIG. **17** is a sectional side view of still another embodiment of a two-stage extensible boom according to the present invention;

FIG. **18** is a sectional view of the extensible boom taken along line **18—18** of FIG. **17**;

FIG. 19 is a sectional side view of a further embodiment of a two-stage extensible boom according to the present invention;

FIG. 20 is a sectional side view of a still further embodiment of a two-stage extensible boom according to the present invention;

FIG. 21 is a sectional side view of another embodiment of a two-stage extensible boom according to the present invention;

FIG. 22 is an enlarged sectional view taken along line 22—22 of FIG. 21;

FIG. 23 is a sectional view taken along line 23—23 of FIG. 22;

FIG. 24 is a sectional side view of a still further embodiment of a two-stage extensible boom according to the present invention showing an extended state;

FIG. 25 is a sectional side view of the extensible boom shown in FIG. 24;

FIG. 26 is an enlarged sectional side view, partly cutaway, of a part of the extensible boom shown in FIG. 25;

FIG. 27 is a sectional view taken along line 27—27 of FIG. 26; and

FIG. 28 is a rear view of the part shown in FIG. 26.

DETAILED DESCRIPTION

Referring now to the drawings, wherein like numerals designate like parts throughout the various figures thereof, one embodiment of an extensible boom, constructed in accordance with the present invention is designated by the reference numeral 1 and illustrated in FIGS. 1, 2 and 3.

The extensible boom 1 includes an outer boom member 2 telescopically receiving an inner boom member 3 therein and an inverted hydraulic cylinder unit 4, the piston-rod 5 of which is pivotally connected at its free end portion to the lower end portion of the outer boom member 2 by suitable means such as pin 6 and the cylinder 7 of which is pivotally connected at one end portion to the lower end portion of the inner boom member 3, as generally indicated by the reference numeral 8.

In accordance with the present invention, a buckle-preventing device 9 is provided within the boom 1 and comprises supporting legs 10 with shoes 10*a* slidably engaged with the inner circumference of the outer boom member 2 and a boss 11 slidably mounted on the piston rod 5. The shoes 10*a* may be interchanged with rollers 10*b* shown in FIG. 9.

The device 9 further includes two pulleys 12 and 13 the shafts of which are secured to legs 10. One of the pulleys 12 trains or carries a wire rope 14 which is suitably fastened at one end to the lower end of the inner boom member 3 at 15, the rope extending around the pulley 12 in U-letter-shaped manner and being suitably fastened at the other end to the upper end of the outer boom member 2 at 16. In like fashion, pulley 13 trains or carries a wire rope 17 which is fixed at one end to the lower end of the inner boom member 3 at 18, and which is turned in a U-letter-shaped manner successively at a pulley 19 rotatably mounted onto the upper end of the outer boom member 2, a pulley 20 rotatably mounted onto the lower end of the boom member 2 and the pulley 13, the rope being fixed at the other end to the lower end of the outer boom member 2 at 21.

With the buckle-preventing device connected to extensible boom 1 in the aforementioned manner, wire rope 14 causes boss 11 and supporting legs 10 to move forwardly or away from the pin 6 as cylinder 7 moves the boom to its extended position. More particularly, the incremental movement of boss 11 is one-half that of piston 7, so that the boss always is maintained equivalent distances from the cylinder and the free end of the piston-rod 5. As illustrated in FIG. 2, when cylinder 7 has moved a distance L, boss 11 has moved a distance one-half L. In like manner, boss 11 is moved downwardly or towards pin 6 by the wire rope 17 when the extensible boom 1 is contracted, the boss continuously being maintained equivalent distances from the cylinder and pin 6.

It is to be understood that, for sake of clarity, the pulleys 12 and 13 have been illustrated as being mounted on individual shafts which extend axially along different lines and do not lie on a same line as illustrated in the embodiment shown in FIGS. 1, 2 and 3. for a smooth operation it is preferable to mount both of the pulleys on a common shaft or on respective shafts lying on a common line.

In addition, although an inverted hydraulic cylinder unit 4 and two-stage boom have been shown, it is to be understood that the present invention can be applied to a boom with a normally postured hydraulic cylinder unit (see FIG. 4) and also to a multistage extensible boom having more than three boom members (see FIG. 5). In FIG. 5, numeral 4_1 designates an additional hydraulic cylinder unit for a third boom member, numeral 9_1 designates an additional buckle-preventing device, and 14_1 and 17_1 designate wire ropes for moving the additional device 9_1 in the three stage extensible boom in connection with the extending and contracting operations of the cylinder unit 4_1 respectively.

Each of the embodiments of the present invention shown in FIGS. 1 through 5 provides driving means for buckle-preventing device wherein said device is moved by a wire rope which is fixed at one end to a suitable portion of a boom member carrying a cylinder of a hydraulic cylinder unit, is trained over a pulley provided in the buckle-preventing device in such a manner that said rope is turned at said pulley in U-letter-shaped manner, and is fixed at the other end to an end of a boom member carrying a piston-rod of said cylinder unit,at which end the latter boom member is integrated with the former boom member, and a wire rope, which is fixed at one end to said integrated end of the former boom member, is trained over two pulleys rotatably mounted onto both ends of the latter boom member and another pulley provided in the buckle-preventing device successively in such a manner that said latter rope is turned at each of said latter three pulleys in U-letter-shaped manner, and is fixed at the other end to the non-integrated end of the latter boom member.

Turning to FIG. 6, a further embodiment of the present invention is illustrated. In this embodiment, four equally circumferentially spaced elongated racks 22 (only two of which are shown) are secured to the external sides of cylinder 7 and extend parallel to the extending and contracting direction of an extensible boom 1. As illustrated in FIG. 6, the racks 22 extend from the right end of the cylinder and terminate approximately in the middle thereof. In addition, four elongated racks 23 are provided on the inner surface of

the inner boom member 3 in confronting face-to-face relationship to respective racks 22, the racks 23 extending from the left end of member 3 to approximately the middle thereof. Four pinions 24 (two of which are shown) are provided on opposite sides of cylinder 4 and engage confronting racks 22 and 23, as illustrated in FIG. 6. Each of the pinions 34 includes a bearing which is connected to the aforedescribed type of buckle-preventing device 9 by means of rods 25.

It is readily apparent that as the piston 5 of FIG. 6 is moved between its contracted and extended position for moving inner boom member 3 in a similar manner, the racks 23 are moved the same distance relative to stationary racks 22. In this manner, the pinions 24, through connecting rods 25, move device 9 one-half of this distance, in the extending or contracting direction of the boom 1, whereby the device is always positioned at an intermediate position between the free end of the extended piston-rod 5 and the cylinder 7.

In addition, when the pinions 24 are engaged with racks 22 provided on the outer circumference of the cylinder 7 at equally circumferentially spaced intervals (only racks 22 at upper and lower sides are shown in FIG. 6), the free end of the cylinder 7 is supported to the inner boom member 3 by the four pinions 24 so that the hydraulic cylinder unit 4 is given an increased resistivity against buckling thereof.

Although a normally postured hydraulic cylinder unit 4 is employed in the embodiment shown in FIG. 6, driving means for the buckle-preventing device 9 comprising racks and pinions can also be employed when an inverted or upside-down hydraulic cylinder unit is used, as, for example, shown in FIG. 7. In the embodiment shown in FIG. 7, a fixed rack 23 is secured on the inner longitudinal circumference of the inner boom member 3 and in confronting relationship with a rack 22 which is fixed at one end to the lower end of an outer boom member 2 at 26 and which extends into inner boom member 3 where it is attached to a roller 27 and rotatable within and along the lower end of the inner boom. while the roller 27 is shown attached to rack 22 and movable along the inner surface of boom member 3, it is to be understood that the roller may be fixed to the inner boom and positioned in rotatable engagement with the back of the rack 22 for serving the same function. In either case, the racks include a pinion 24 and rod 25 connected to device 9 for moving device 9 in the same manner as discussed with regard to FIG. 6.

It is to be understood that driving means for the buckle-preventing device 9 comprising a combination of racks and pinions can also be employed to a multistage extensible boom having more than three boom members, as shown, for example, in FIG. 8. In FIG. 8, numeral 4_1 designates an additional hydraulic cylinder unit for a third boom member, numeral 9_1 designates an additional buckle-preventing device, 22_1 and 23_1 and 25_1 an additional connecting rod, respectively, all of which operate in the same manner as described with respect to FIGS. 6 and 7.

Each of embodiments of the present invention shown in FIGS. 6, 7 and 8 provides another driving means for the buckle-preventing device wherein said device is moved by bearing means for a pinion or pinions engaging with a pair of racks at the same time which racks are provided at definite portions on the cylinder of a hydraulic cylinder unit or a boom member carrying said cylinder and on a boom member carrying the piston-rod of said cylinder unit in face-to-face and parallel relation.

Turning to FIGS. 9 and 10, attention is directed to another embodiment of the present invention. In the extensible boom 1 shown in FIGS. 9 and 10, four equally circumferentially spaced rollers 28 covered with plastic tires such as gum tires are provided between and in engagement with the upper half portion of a cylinder 7 and the lower half portion of an inner boom member 3. The bearings 29 of rollers 28 are connected to a buckle-preventing device 9 by rods 30. This construction provides an advantage over the embodiments of FIGS. 7 and 8 in that there is no need for the aforementioned racks. In this extensible boom 1, when the piston-rod 5 is extended by an optional distance, the rollers are moved or rolled along the outer circumference of the cylinder 7 and the inner circumference of the boom member 3 so that the device 9 is moved with the rollers 28 by a distance one-half of extended distance of the piston-rod 5, whereby the device 9 is always positioned at an intermediate position between the free end portion of the extended piston-rod 5 and the lower end of the cylinder 7.

With the utilization of at least a pair of rollers 28 provided on the outer circumference of the cylinder 7, as is the case in the embodiment shown in FIGS. 9 and 10, and in the event of a buckling load being applied to the cylinder unit 4, at least one of the rollers 28 will always be in engagement with both the cylinder 7 and the inner boom member 3, whereby the movement of the device 9 toward the extending or contracting direction is guaranteed more surely than if only a single roller 28 were provided. However, when four rollers 28 are arranged equally circumferentially around the cylinder 7, as illustrated in FIG. 10, the free end portion of cylinder 7 is supported to the inner boom member 3 through these four rollers 28, for enhancing the resistivity against buckling of hydraulic cylinder unit 4 at the portion thereof where the rollers 28 are positioned.

FIG. 11 shows a modification of the embodiment shown in FIGS. 9 and 10. In this embodiment wherein an inverted or upside-down hydraulic cylinder unit 4 is arranged in an extensible boom 1, there is provided an additional plate member 31, one end of which is fixed at 32 to the lower end portion of an outer boom member 2 which is also connected to a piston-rod 5 of the cylinder unit 4, the plate member extending longitudinally into inner boom member 3, as illustrated in FIG. 11. Further, a pair of rollers 28 are positioned for rolling engagement between and to plate member 31 and an inner boom member 3, the bearings of rollers 28 being connected to a buckle-preventing device 9 by rods 30, so that device 9 can be moved with aid of the rolling action of the rollers 28 in the same manner as described in the embodiment shown in FIGS. 9 and 10.

FIG. 12 shows a modification of the rollers 28 used in the above embodiment of FIG. 11, which modification is directed towards reducing the diameters of such rollers as well as the need for rollers with accurately dimensioned diameters. In this preferred modification, a plurality of rollers 28_1, 28_2 and 28_3 are provided and are rotatably mounted on bearing means 34 pivotally

connected to the end of rod **30** at **33**, the rollers operating in connection with one another. The rollers 28_3 and 28_1 which pivot about intermediate roller 28_2 along with bearing means **34**, are respectively forced against the inner boom member **3** and the plate member **31** with aid of a spring **35** provided in the bearing means **34**, respectively. In this manner, the rollers 28_1, 28_2 and 28_3 provide the same function as a single roller **28** of FIG. **11**.

It is to be understood that the driving means for the buckle-preventing device **9** used in the embodiment shown in FIG. **11** can also be applied to a multi-stage extensible boom having three or more boom members by providing the required numbers of plate members **31**. In the three-stage extensible boom shown in FIGS. **13** and **14**, plate members **31***a* and **31***b* are fixed at common ends thereof to respective boom members **1** and **2** at **32***a* and **32***b* and are supported at their free end portions, by the means shown in FIG. **14**. That is, the plate member **31***a* is engaged between supporting rollers **36***a* and **36***b* rotatably mounted on one-stage higher boom member **2** so as to keep the plate at a definite position. In addition, bearing means **34***a* provided with a roller **28***a* for moving buckle-preventing device **9***a* includes two rollers 37_1 and 37_2 positioned on opposite sides of roller **28***a*. Rollers 37_1 and **28***a* receive therebetween and engage opposite sides of the plate member **31***a* while the rollers 37_2 and **28***a* receive therebetween and engage opposite sides of plate member **31***b*, whereby the plate members **31***a* and **31***b* are kept at definite positions which ensures the engagement of the roller **28***a* therewith. Furthermore, a roller **28***b* (FIG. **13**) for moving a buckle-preventing device **9***b* is rotatably engaged against the plate member **31***c* and the inner circumference of the boom member **3**, the plate member **31***c* being fixed at one end to the lower end of boom member **2** and extending into boom member **3** as illustrated in FIG. **13**.

Any of the embodiments shown in FIGS. **9** through **14** provides driving means for the buckle-preventing device wherein said device is moved by a roller (rollers) which is (are) slidably engaged with the cylinder, a boom member carrying the cylinder or a plate member fixed to a suitable portion of said boom member, and also a boom member carrying the piston-rod or a plate member fixed to a suitable portion of said boom member.

Attention is directed to FIGS. **15** and **16** for a further embodiment of the present invention. In this embodiment, a buckle-preventing device **9** is provided with a rotary drum **40** the longitudinal shaft **39** of which is supported to the device **9** in a direction transverse of the movement of the device. Between the drum **40** and the extending and contracting boom members, there is provided a pair of wire ropes **45** and **46** common ends of which are fixed to an outer boom member **2** and the inner boom member **3**, respectively, at suitable positions **41** and **42** (in this case, at the lower end portions of said members) under a condition where the boom **1** is fully extended. The otherwise free common ends of ropes **45** and **46** are fixed to the drum **40** at **43** and **44**, respectively. Further, between the drum **40** and the buckle-preventing device **9**, there is provided a plate spring **47** the ends of which are fixed to the drum **40** at **48** and to the device **9** at **49**, the plate spring forceably rotating the drum **40** in such a direction that the ropes **45** and **46** will be wound up around the drum. When a piston-rod **5** is extended or contracted by an optional distance, the drum **40** is rotated with or against the force of the spring **47** so that the pair of wire ropes **45** and **46** are wound up or unwound under tension, whereby the device **9** is moved by a half of the extended or contracted distance of the piston-rod **5**. In this way, the device is always positioned at an intermediate position between the free end portion of the extended piston-rod **5** and the lower end of the cylinder **7**.

Though an inverted or upside-down hydraulic cylinder unit **4** and a two stage extensible boom are shown in FIGS. **15** and **16**, the driving means for the buckle-preventing device shown in FIGS. **15** and **16** can, of course, be applied to a multi-stage extensible boom having any number of boom members and provided with normally postured hydraulic cylinder units, as can now clearly be understood by those skilled in the art. Thus, this embodiment further provides compact driving means for the buckle-preventing device wherein said device is moved by a rotary drum which is rotatably mounted to the device and which is always forced in such a direction that wire ropes or chains will be wound up on said drum, the wire ropes or chains being fixed to the drum at common ends and to the relatively extending and contracting boom members.

In briefly summarizing the preferred embodiment of the present invention as illustrated in FIGS. **1** through **16**, a device is provided for substantially eliminating buckling of a hydraulic cylinder unit which is used for driving an extensible boom. The buckle-preventing device is positioned around the piston-rod of the cylinder unit within one of the boom members and includes outwardly extending legs which slidably or rotatably engage the inner surface of the boom member for longitudinally moving the device therethrough. Various types of driving means (as illustrated in the various figures) are provided for moving the device along with the piston-rod (or cylinder component) such that the device is always positioned at substantially an intermediate point between the free end of the piston-rod and the end of cylinder of said cylinder unit. In this manner, the piston-rod is always supported with the buckle-preventing device at what is otherwise the critical buckling point whereby resistance against such buckling becomes effectively increased at any extended state of said rod. Therefore, according to the present invention, the weight of the hydraulic cylinder unit can be decreased correspondingly, so that an extensible boom with a longer scale can be obtained without increasing substantial weight and cost.

The following are further detailed embodiments of driving means for the buckle-preventing device. One such embodiment is illustrated in FIGS. **17** and **18**. In this embodiment, the buckle-preventing device **9** is spring-biased in the direction of arrow A by a spring **50***a* provided between said device **9** and a suitable portion of the cylinder **7**. A rod member **52** having a stopper **51** at the uppermost portion is slidably inserted through the device and has its other end secured to the free end portion of piston-rod **5**. In this manner, the device **9** is biased into engagement with the lower end of the cylinder **7**, due to the force of the spring **50***a*, so

long as the hydraulic cylinder unit 4 is in a contracted state or in an extended state with an extended distance equal to or shorter than a definite L, the effective length of the rod 52. Therefore, the device 9 is moved in the outer boom member 2 along with the cylinder 7 through the distance L. However, when the piston-rod 5 is extended by a distance greater than the aforementioned distance L, the rod member 52 prevents further movement of the device 9 in the outer boom member (FIG. 17) so that the span between the device 9 and the pivot 6 of the piston-rod 5 is maintained at the aforementioned definite distance L. The distance L is preferably designed so as to correspond to one-half of the fully extended span of the piston-rod 5, so that the device 9 is positioned substantially intermediate the free end of the piston-rod and cylinder 7. Further, in the embodiment shown in FIGS. 17 and 18, there is provided a rod member 53 which has one end secured to the device 9, and the other end, including a stopper 54, slidably inserted into a bracket 55 fixedly mounted on the outer circumference of the cylinder 7. The rod member 53 serves for preventing the interval between the device 9 and the cylinder 7 from being enlarged more than the definite one L.

Though an inverted or upside-down hydraulic cylinder unit 4 is employed in the embodiment shown in FIGS. 17 and 18, driving means for the buckle-preventing device according to the present embodiment can also be applied to an extensible boom with a normally postured hydraulic cylinder unit 4, as can be understood with reference to FIG. 19. Further, although the device 9 and the cylinder 7 are connected through spring 50*a* and a rod member 52 is arranged between the device 9 and the free end of the piston-rod 5 so as to keep the interval between the device 9 and said free end substantially equal to a definite distance when the unit 4 is in an extended state (as illustrated in FIG. 19) the device 9 may be so constructed that the interval between the device and the cylinder 7 is maintained fixed (for example, a distance L) when unit 4 is in its most extended state. This is achieved by connecting the device 9 to the free end of the piston-rod 5 by means of a spring and by arranging the aforementioned type of a rod member between the device and the cylinder. Furthermore, even if the spring 50*a* shown in FIG. 17 is omitted, the device 9 will be positioned substantially intermediate the free end of piston-rod 5 and cylinder 7 when the cylinder unit is in its fully extended position as limited by rod members 52 and 53.

In addition, more than two buckle-preventing devices may be provided with a piston-rod, as illustrated in FIG. 20. in this embodiment, two buckle-preventing devices 9*a* and 9*b*, each of which is constructed in the same manner as buckle-preventing device 9, are provided about the piston-rod 5 of cylinder unit 4. These two devices 9*a* and 9*b* are connected to each other with a spring 50*b*. Further, a rod member 53*a* having an end stopper 54*a* connects the device 9*a* and the cylinder 7 while a rod member 52*b* having an end stopper 54*b* connects the device 9*b* and the free end of piston-rod 5 so that the respective intervals between the device 9*a* and the cylinder 7 and between the device 9*b* and the free end of the piston-rod 5 are maintained fixed when the hydraulic cylinder unit 4 is fully extended.

It is to be understood that the rod members 52, 53, 52*b* and 53*a* shown in FIGS. 17 through 20 may be substituted with wire ropes, chains or the like having definite length. Further, although springs 50*a* and 50*b* are of the pulling type as illustrated in FIGS. 17 through 20, compression springs may be used for the same purpose when they are arranged in parallel arrangements with the rod members so as to keep said springs straight.

Each of embodiments of the present invention shown in FIGS. 17 through 20 provides another driving means for the buckle-preventing device wherein said device is moved during the extension of a hydraulic cylinder unit by a spring or a rod member while keeping the interval between the device and the free end of the piston-rod or between the device and the cylinder fixed when the hydraulic cylinder is in an extended state.

A further embodiment of the present invention is illustrated in FIGS. 21, 22 and 23. In this embodiment, restraining means are provided between the buckle-preventing device 9 and an inner boom member (although said means may be provided between the device 9 and the cylinder 7) which includes a pair of substantially diametrically aligned hooks 59 pivotally mounted on brackets 56 at 57 and spring forced in the direction of arrow B by means of associated springs 58. Each hook 59 includes an arm portion having a roller 60 rotatably mounted thereto. Each hook 59 is biased in a position shown in FIG. 21 (the same position is illustrated by imaginary lines in FIG. 23) when its associated roller 60 is in rotatable engagement with the inner circumference of the outer boom member 2. However, each of the hooks 59 is forced into a restraining position, as illustrated by solid lines in FIG. 23, when its roller 60 engages an associated cam surface 61 provided on the inner circumference of the outer boom member 2.

As the hydraulic cylinder unit 4 is extended from its contracted state by a definite distance L, the hooks 59 engage pins 62 projecting from the legs 10 of the buckle-preventing device 9, as seen best in FIG. 22. However, when the cylinder unit 4 is extended by a distance longer than the distance L, each of the rollers 60 engages and rides on an associated cam surface 61 causing the hook 59 to move from its biased position to its restrained position for disengaging the hook from pin 62 and therefore disengaging the hook from device 9. In this manner, the device 9 is restrained at a definite position in the outer boom member 2, namely at a position apart from the free end of the piston-rod 5 by a definite distance L corresponding to substantially one-half of the fully extended span of the piston-rod 5. The device 9 is kept at this position with the aid of optional means such as frictional resistance provided between the device 9 and the inner circumference of the outer boom member 2 or between the device 9 and the piston-rod 5. When the cylinder 7 extends beyond this point, the hooks 59, of course, move back to their biased positions.

When the hydraulic cylinder unit 4 is contracted from its fully extended state, the rollers 60 again are brought into riding engagement with cam surfaces 60 whereby hooks 59 are driven to their restrained positions for receiving associated pins 62. Further movement of the unit 4 towards its contracted position

causes the hooks to move to their biased positions and into engagement with the pins so that the device **9** is necessarily moved together with the cylinder **7** when the cylinder unit **4** is contracted still further. In addition, there is provided a little backlash between the device **9** and the cylinder **7** in said restraining state.

In the embodiment shown in FIGS. **21**, **22** and **23**, an inverted or upside-down hydraulic cylinder unit **4** is arranged in an extensible boom **1**. However, it is to be understood that driving means for the buckle-preventing device **9** according to this embodiment can also be applied to an extensible boom in which a normally postured hydraulic cylinder unit is arranged, as hereinafter detailed with reference to the embodiment shown in FIGS. **24** through **28**. In this embodiment, there are provided particular restraining means which limit the buckle-preventing device **9** to a desired intermediate position on the extended piston-rod without relying upon the aforementioned frictional resistance, or the like.

Specifically, bracket **63** (FIG. **26**) is secured to the top portion of the cylinder **7** upon which a first hook **64** is pivotally mounted at **65**, the hook being spring biased in the direction of arrow C by spring means **69**. A roller **66** is pivotally mounted on one end portion of first hook **64**. While the first hook **64** is always restrained by a stopper **67** projecting from bracket **63**, or a pin **68** projecting from device **9**, the hook is moved into the reverse direction of arrow C and out of engagement with the pin **68** when the roller **66** rides on a cam **70** provided on the inner circumference of the inner boom member **3** at an intermediate position thereof.

Turning to FIG. **28**, a second hook **72** is pivotally mounted to the inner circumference of the inner boom member **3**, at a point **73** in approximately the middle of the boom member, the second hook **72** being spring forced or biased in the direction of arrow D by means of a spring **71**. In its biased position, the second hook **72** is restrained by a pin **74** projecting from the inner boom member **3**. The base end of a lever **75** is pivotally connected to the inner circumference of boom member **3** at **76**, and a spring **77** is arranged between the other end of lever **75** and a suitable portion of the second hook **72**. The second hook **72** is restrained with the force of spring **71** on the aforementioned pin **74** or a pin **78** projecting from the device **9** so as to be maintained at a definite position (FIG. **28**). However, the hook **72** is moved in the reverse direction of arrow D, against the force of the spring **77**, when the lever **75** is operated by a pin **79** projecting from the upper portion of the cylinder **7**, as well as by an inclined plane **72***a* provided at the front portion of the hook **72** when the plane engages the pin **78**.

Operationally, in the embodiment shown in FIGS. **24** through **28**, the first hook **64** engages pin **68** so that the buckle-preventing device **9** is restrained at the upper end portion of the cylinder when the piston-rod **5** is in its contracted state (FIG. **25**). When the inner boom member **3** has been extended to an intermediate position, the first hook **64** leaves the pin **68** with the aid of the roller **66** and the cam **70**, and the second hook **72** becomes automatically engaged with the pin **78** due to the engagement of the inclined plane **72***a* and pin. Thereafter, the device **9** is moved together with the piston-rod **5** during extension thereof, so that said device **9** is positioned at an intermediate position of the inner boom member **3** (FIG. **24**). When the piston-rod **5** is contracted from the above state, the device **9** is moved together with the contraction of the piston-rod **5** and the pin **68** is passed along the inclined plane **64***a* to engage the first hook **64**. At the same time, the second hook **72** is moved into the reverse direction of arrow D, due to the operation of the lever **75** by the pin **79**, and is released from engagement with the pin **78** so that the piston-rod **5** is further contracted to its original state. Therefore, the device **9** can be maintained substantially in the middle of piston-rod **5** when the latter is in its fully extended position.

In each of embodiments of the present invention, as shown in FIGS. **17** through **28**, the buckle-preventing means can be constructed such that, when the piston-rod has been extended by a definite distance, the buckle-preventing device is moved to a predetermined point on the extended piston-rod, said piston-rod being supported at a suitable intermediate position by the buckle-preventing device which is slidably or rotatably engaged with the inner circumference of the outer or inner boom member, and the maximum span of the piston-rod between the device and the free end of the piston-rod and between the device and the cylinder always being kept shorter than said definite distance, for example, about a half of the length of the fully extended piston-rod, whereby resistance against buckling of the extended piston-rod is increased correspondingly. thus, according to the present invention, the weight of such a hydraulic cylinder unit can be decreased in proportion to the increase in resistance against buckling of the piston-rod. In addition, when utilizing an inverted or upside-down hydraulic cylinder unit, the buckle-preventing device is kept in contact with the lower end of the cylinder until the cylinder unit has been extended to an intermediate state, as is the case in the embodiments shown in FIGS. **17** and **18** and FIGS. **21** through **23**, namely when the device is moved only at the beginning period of extending operation and the closing period of contracting operation of the hydraulic cylinder unit. Therefore, the buckle-preventing device is moved before the piston-rod has a chance to buckle, so that the device can be moved in a substantially smooth manner. Furthermore, when an inverted or upside-down cylinder unit is employed, the cylinder of such unit can be pivoted or fixed to the inner boom member at the lower end portion of said member whereby to increase the resistance against buckling.

In addition, although a two-stage extensible boom is illustrated in each of the embodiments shown in FIGS. **17** through **28**, each feature particularly disclosed in said embodiments can also be applied, added or mutually interchanged for multi-stage extensible booms having optional numbers of telescopically extensible boom members and hydraulic cylinder units arranged between two adjacent boom members. Further, although a piston-rod is provided with only one buckle-preventing device in each of the embodiments, except for that embodiment shown in FIG. **20**, each feature particularly disclosed in said embodiment can be applied, so long as no contradiction results, to modified buckle-preventing means wherein two or more than two buckle-preventing devices are provided to a piston-

rod, and each of said devices is brought to a controlled position when the piston-rod is extended.

Thus, the present invention is in no way limited to the embodiments particularly described hereinbefore, and it is to be understood that innumerable variations, applications, modifications and extensions of the basic principles involved may be made without departing from its scope. The invention is to be limited, therefore, only by the scope of the appended claims.

What is claimed is:

1. In an extensible boom of the type having at least one pair of telescopically extensible inner and outer boom members and at least one hydraulic power unit arranged between the ends of adjacent inner and outer boom members for producing relative movement between said boom members, said power unit including a hydraulic cylinder connected to one of said boom members, and a piston rod connected to the other of said boom members; buckle-preventing means for said piston rod, said buckle-preventing means comprising: a body portion slidably received on said piston-rod of said power unit, said body portion having outwardly extending means movably engaged with the inner circumference of the boom member to which the end of the piston is connected, and driving means for moving said body portion through said boom in response to the extending and contracting operation of said hydraulic cylinder unit, said driving means including means operably connecting said body portion to said adjacent boom members moving said body portion continuously during said extending and contracting operation as a function of the relative movement between said members and at a rate smaller than the extending and contracting rate of said hydraulic cylinder unit, whereby said body portion is substantially continuously maintained intermediate the end of said piston-rod connected to the other boom member and the end of said cylinder.

2. A device according to claim 1 wherein said driving means includes a first pulley mounted to said body portion and rope means fixed at one end to a suitable portion of a boom member carrying said cylinder, said rope means being trained over and around said pulley and fixed at its other end to one end of a boom member carrying said piston-rod, second and third pulleys mounted to opposite ends of said piston-rod carrying boom member, a fourth pulley mounted to said body portion, and second rope means fixed at one end to one end of said cylinder carrying boom member, said second rope means being trained over and around said second, third and fourth pulleys in such a manner that said latter rope means is turned at each of said latter three pulleys in a U-letter-shaped manner, and is fixed at the other end to the other end of said piston-rod carrying boom member.

3. A device according to claim 1 wherein said driving means includes first rack means fixed within the boom member carrying said cylinder, second rack means fixed within the boom member carrying said piston-rod and in confronting relationship with said first rack means, and pinion means positioned between and in engagement with said rack means, said pinion means being connected to said body portion for moving the latter in response to the extending and contracting operation of said cylinder.

4. A device according to claim 3 wherein said first and second rack means includes a plurality of first racks provided around and mounted to the outer circumference of said cylinder, an equal plurality of second racks provided around and mounted to the inner circumference of said inner boom, each of said second racks being in confronting relationship with a corresponding one of said first racks, and an equal plurality of pinion means for supporting said cylinder, each of said pinion means being provided between and in engagement with a confronting pair of said racks.

5. A device according to claim 4 wherein said rack means is fixed at one end to its corresponding boom member and wherein said driving means further includes roller means supporting said last mentioned rack means for ensuring engagement between said pinion means and said last mentioned rack means.

6. A device according to claim 1 wherein said driving means includes a plurality of roller means connected to said body portion, said roller means being in rotatable engagement with relatively movable surfaces carried by said inner and outer boom members, respectfully, whereby to move said body portion.

7. A device according to claim 6 including a first elongated plate member positioned within and affixed to one of said boom members, a second elongated plate member positioned within and affixed to the adjacent boom member, said plate members providing said relatively movable surfaces for rotatable engagement with said roller means.

8. A device according to claim 7 wherein one of said plate members is fixed at one end to its corresponding boom member and wherein said driving means further includes second roller means mounted to the other boom member, said second roller means being positioned for rotatable engagement with said last mentioned plate member whereby to aid in supporting said last mentioned plate member.

9. A device according to claim 8 wherein one of said plate members is fixed at one end to its corresponding boom member and wherein said driving means further includes second roller means rotatably mounted to a bearing provided with said first roller means, said second roller means being in rotatable engagement with said last mentioned plate member for insuring engagement between said first roller means and said last mentioned plate member.

10. A device according to claim 9 wherein said roller means includes a first roller rotatably engaging both of said plate members, a second roller rotatably engaging said first plate member and a third roller rotatably engaging said second plate member.

11. A device according to claim 1 wherein said driving means includes drum means rotatably mounted to said body portion, a pair of rope means secured at common ends to said drum means and at opposite common ends to said adjacent boom members respectively and means for rotatably biasing said drum in a direction such that said ropes are wound thereupon.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,722,154 Dated March 27, 1973

Inventor(s) Teruya Sakamoto, Takemi Nishimura & Osamu Takarada

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

Col. 4, line 20, change "for" to --For--

Col. 5, line 7, change "34" to --24--

Col. 13, line 30, after"members" insert --and--

Signed and sealed this 20th day of November 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334