DRIVE SYSTEM FOR A TELESCOPIC BOOM

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Filed: May 17, 1973

Appl. No.: 361,130

U.S. Cl. 52/118, 52/119, 182/141, 52/121

Int. Cl. E04h 12/34

Field of Search 52/111, 115, 118, 119, 52/121; 182/141, 2; 92/137, 140, 146

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ABSTRACT

A truck mounted, extensible, telescopic boom is rotatably connected to a turret and pivoted about an axis by an elevation cylinder. In one embodiment, the length of the boom is altered in response to changes in elevation by an extension cylinder which connects to an outer boom section and to the turret at a point substantially above the boom pivot axis. In a second embodiment, the same action is obtained with an extension cylinder connected to a trolley which is slidably mounted to the boom. The extension cylinder in this instance connects to the turret at a point which is substantially below the boom point axis and boom reach is altered by the sliding motion of the trolley. In both embodiments, the extension cylinder operates to retract outer boom sections as the boom elevation is reduced, and to thereby reduce reach and overturning moments when the boom is lowered.

7 Claims, 4 Drawing Figures
DRIVE SYSTEM FOR A TELESCOPIC BOOM

BACKGROUND OF THE INVENTION

The field of the invention is extensible telescopic booms, and particularly drive means for extending and elevating such booms.

Extensible telescopic booms are used in a wide variety of applications, including truck mounted cranes, aerial lifts, and splicers. Such booms are mounted to the truck bed and are comprised of two or more boom sections which telescope one within the other. The lower, or base boom section, is rotatably connected to the truck bed for pivotal motion in a vertical plane and is generally mounted on a turret which may be revolved to swing the boom to any desired orientation. Rope and pulley systems, or hydraulic cylinders, are commonly used to extend and retract the boom sections and to thereby provide a means of controlling boom reach.

Particularly when mounted on trucks, means must be provided to insure that the operator does not orient the boom in an unstable position. Such instability may result, for example, when the boom is fully extended at a low elevation, and is swung to the side of the truck causing it to tip. Counterweights and audio or visual warning devices are often provided to minimize this possibility, however, there is a limit to the amount of counterweight which can be added to an "over-the-road" vehicle, and warning devices are expensive and subject to malfunction.

The problem is particularly acute where the operator is located in a basket attached to the end of the boom. Interlock systems have been employed that include cams and limit switches which prohibit the operator from orienting the boom in an unstable position. Such an interlock system is disclosed, for example, in U.S. Pat. No. 2,936,847 issued to Eitel on May 17, 1960, which includes a series of cam actuated switches that prevent the operator from positioning the boom in an unsafe orientation by disabling the swing drive or the elevation drive until the boom reach is reduced to a safe length. Such electromechanical systems are expensive to maintain and subject to malfunctions.

SUMMARY OF THE INVENTION

The present invention relates to a means of altering boom reach in response to changes in boom elevation. More specifically, an extensible telescopic boom has a base section connected to a turret for pivotal action in a vertical plane about a boom pivot axis, an extensible outer boom section slidably connected for telescopic motion with respect to the base boom section, and an extension cylinder having one end connected to the outer boom section and its other end connected to the turret at a point which is laterally displaced from the boom pivot axis. By laterally displacing the extension cylinder connection point from the boom pivot axis, the boom reach which is controlled by the extension cylinder becomes a function of boom elevation. That is, as the boom is lowered, its length is reduced by the extension cylinder even though the length of the extension cylinder remains constant. Consequently, as the operator raises and lowers the boom, its length is adjusted by the action of the extension cylinder and stability is automatically maintained at all times.

A general object of the invention is to provide a boom extension drive system which is dependent on boom elevation. When the extension cylinder connection point is laterally displaced above the boom pivot axis, its other end may be connected directly to the outer boom section. However, if the extension cylinder connection point is below the boom pivot axis, a trolley slidably mounted to the base section must be provided to obtain the desired reduction in boom reach as boom elevation is reduced. In this instance the end of the extension cylinder connects to the trolley and a rope and pulley drive system is operated by the motion of the trolley to extend and retract the outer boom section.

A more specific object of the invention is to provide an extension drive system for a three-part boom. A first rope and pulley drive system connects to the base boom section and a mid boom section. It includes and is operated by the trolley which is slidably connected to the base boom section. A second rope and pulley drive system connects to the base boom section and an outer boom section. It includes and is operated by pulleys rotatably attached to the mid boom section.

Still another object of the invention is to provide a substantial reduction in boom reach as its elevation is reduced. The first rope and pulley drive system which includes the trolley may be configured to provide a displacement gain which amplifies the boom reach reduction.

The foregoing objects and advantages of the invention will appear from the following description.

In the description reference is made to the accompanying drawings which form a part hereof, and in which there is shown by way of illustration preferred embodiments of the invention. Such embodiments do not necessarily represent the full scope of the invention, but rather the invention may be employed in many different embodiments and reference is made to the claims herein for interpreting the breadth of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a first preferred embodiment of the invention,

FIG. 2 is an elevation view with parts cut away of a truck mounted boom which incorporates a second, preferred embodiment of the invention.

FIG. 3 is a cross section of the boom of FIG. 2 with parts cut away and some parts left out to more clearly illustrate the invention, and

FIG. 4 is a view in cross section of the boom of FIG. 3 taken on the plane 4—4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, an extensible, telescopic boom is comprised of a base section 1 and an outer section 2. The lower end of the base section 1 is rotatably connected to a pedestal 3 to pivot in a vertical plane about a boom pivot axis 4. The blind end of an elevation cylinder 5 is also rotatably connected to the pedestal 3 and a rod 6 thereof rotatably connects to an ear 7 which is integrally formed to the underside of the base boom section 1. The elevation cylinder 5 is hydraulically operated to raise and lower the boom.

The outer boom section 2 is slidably connected to the base boom section 1 and is operable to extend and retract in telescopic fashion along an extension axis indicated generally by the dashed line 8. The reach, or length of the boom is controlled by an extension cylinder 9 which has its blind end rotatably connected to the
The boom 20 is comprised of three parts, a base section 24, a mid section 25 and an outer section 26. As shown best in FIG. 4, each boom section 24, 25 and 26 is comprised of four panels welded together to form a rectangular shaped cross section, and each is progressively smaller in size to allow a telescopic configuration. Referring to FIG. 2, for example, mid section 25 is contained within base section 24 and is slidably mounted thereto for telescopic motion along an extension axis 14. The slidable attachment is accomplished with a pair of rollers 27 attached to the bottom panel at the outer end of the base section 24 and a pair of rollers 28 which are connected to the upper panel at the lower end of the mid section 25. The rollers 27 carry the weight of the mid section 25 and the rollers 28 bear against the top panel of the base section 24. Additionally, a roller 29 connects to the lower end of the mid section 25 and rides on the bottom panel of the base section 24 when the mid section is extended or retracted. Similarly, the outer section 26 is slidably mounted to the mid section 25. A pair of rollers 30 connect to the bottom panel at the outer end of the mid boom section 25 to bear against and support the underside of the outer boom section 26. Also, a pair of rollers 31 connect to the top panel at the lower end of the outer boom section 26 to minimize wear and frictional losses between the outer boom section 26 and the upper panel of the mid boom section 25. This slidable attachment of the three boom sections 24, 25, 26 is well known in the art and, therefore, has not been shown in FIG. 3 in order to more clearly illustrate therein the rope and pulley drive systems which form a part of the present invention. It should be apparent to those skilled in the art, however, that some of the pulleys illustrated in FIG. 3 and described below may be coaxially mounted with the above described rollers.

Referring to FIG. 2, a second, preferred embodiment of the invention is employed in a truck mounted aerial lift. A truck 15 includes a cab 16 appropriately equipped for over-the-road operation. The truck 15 also includes a bed 17, upon which is carried a pair of equipment storage compartments that extend upward along each side of bed 17. A table 18 formed of welded steel members is also attached to the truck bed 17 and is positioned between the equipment storage compartments. A turret 19 is rotatably connected to the table 18 and a hydraulic swing motor (not shown in the drawings) is connected to rotate the turret 19 about a vertical axis.

The turret 19 provides support for a three-part boom 20. The turret 19 is formed from steel plates which extend upward a short distance from the table 18 and then nearly horizontal to form a counterweight portion 21. The counterweight portion 21 divides into two sections and the lower end of the boom 20 is rotatably connected to and suspended between the sections by trunnions 22 which extend outward from each side of the boom 20. The trunnions 22 are journaled to the turret 19 and the boom 20 is thus rotatably connected to pivot in a vertical plane about a boom pivot axis 23.

The boom 20 is comprised of three parts, a base section 24, a mid section 25 and an outer section 26. As shown best in FIG. 4, each boom section 24, 25 and 26 is comprised of four panels welded together to form a rectangular shaped cross section, and each is progressively smaller in size to allow a telescopic configuration. Referring to FIG. 2, for example, mid section 25 is contained within base section 24 and is slidably mounted thereto for telescopic motion along an extension axis 14. The slidable attachment is accomplished with a pair of rollers 27 attached to the bottom panel at the outer end of the base section 24 and a pair of rollers 28 which are connected to the upper panel at the lower end of the mid section 25. The rollers 27 carry the weight of the mid section 25 and the rollers 28 bear against the top panel of the base section 24. Additionally, a roller 29 connects to the lower end of the mid section 25 and rides on the bottom panel of the base section 24 when the mid section is extended or retracted. Similarly, the outer section 26 is slidably mounted to the mid section 25. A pair of rollers 30 connect to the bottom panel at the outer end of the mid boom section 25 to bear against and support the underside of the outer boom section 26. Also, a pair of rollers 31 connect to the top panel at the lower end of the outer boom section 26 to minimize wear and frictional losses between the outer boom section 26 and the upper panel of the mid boom section 25. This slidable attachment of the three boom sections 24, 25, 26 is well known in the art and, therefore, has not been shown in FIG. 3 in order to more clearly illustrate therein the rope and pulley drive systems which form a part of the present invention. It should be apparent to those skilled in the art, however, that some of the pulleys illustrated in FIG. 3 and described below may be coaxially mounted with the above described rollers.

Referring to FIG. 2, a second, preferred embodiment of the invention is employed in a truck mounted aerial lift. A truck 15 includes a cab 16 appropriately equipped for over-the-road operation. The truck 15 also includes a bed 17, upon which is carried a pair of equipment storage compartments that extend upward along each side of bed 17. A table 18 formed of welded steel members is also attached to the truck bed 17 and is positioned between the equipment storage compartments. A turret 19 is rotatably connected to the table 18 and a hydraulic swing motor (not shown in the drawings) is connected to rotate the turret 19 about a vertical axis.

The turret 19 provides support for a three-part boom 20. The turret 19 is formed from steel plates which extend upward a short distance from the table 18 and then nearly horizontal to form a counterweight portion 21. The counterweight portion 21 divides into two sections and the lower end of the boom 20 is rotatably connected to and suspended between the sections by trunnions 22 which extend outward from each side of the boom 20. The trunnions 22 are journaled to the turret 19 and the boom 20 is thus rotatably connected to pivot in a vertical plane about a boom pivot axis 23.

The boom 20 is comprised of three parts, a base section 24, a mid section 25 and an outer section 26. As shown best in FIG. 4, each boom section 24, 25 and 26 is comprised of four panels welded together to form a rectangular shaped cross section, and each is progressively smaller in size to allow a telescopic configuration. Referring to FIG. 2, for example, mid section 25 is contained within base section 24 and is slidably mounted thereto for telescopic motion along an extension axis 14. The slidable attachment is accomplished with a pair of rollers 27 attached to the bottom panel at the outer end of the base section 24 and a pair of rollers 28 which are connected to the upper panel at the lower end of the mid section 25. The rollers 27 carry the weight of the mid section 25 and the rollers 28 bear against the top panel of the base section 24. Additionally, a roller 29 connects to the lower end of the mid section 25 and rides on the bottom panel of the base section 24 when the mid section is extended or retracted. Similarly, the outer section 26 is slidably mounted to the mid section 25. A pair of rollers 30 connect to the bottom panel at the outer end of the mid boom section 25 to bear against and support the underside of the outer boom section 26. Also, a pair of rollers 31 connect to the top panel at the lower end of the outer boom section 26 to minimize wear and frictional losses between the outer boom section 26 and the upper panel of the mid boom section 25. This slidable attachment of the three boom sections 24, 25, 26 is well known in the art and, therefore, has not been shown in FIG. 3 in order to more clearly illustrate therein the rope and pulley drive systems which form a part of the present invention. It should be apparent to those skilled in the art, however, that some of the pulleys illustrated in FIG. 3 and described below may be coaxially mounted with the above described rollers.
The boom extension drive system is comprised generally of an extension cylinder and a pair of rope and pulley drive assemblies. Referring particularly to FIGS. 3 and 4, a hydraulic extension cylinder 45 has one end rotatably connected to the turret 19 by means of a pin 46 journalled between the counterweight sections 21. The extension cylinder 45 includes a rod 47, the end of which is rotatably connected to a trolley 48. The trolley 48 in turn is slidably retained to a track 49 which connects to the underside of the base boom section 24. The track 49 is formed by a pair of spaced, V-shaped side plates 50 and 51 which are welded to the underside of the base boom section 24, and a downward facing channel with opposing sidewalls 52 and 53 is thus formed. A pair of angle irons 54 are welded along the length of the side wall 52 and a pair of angle irons 55 are welded along the length of the side wall 53. A pair of parallel, opposing tracks are thus formed within the channel.

The trolley 48 includes a pair of plates 56 and 66 which are rigidly fastened to one another and spaced apart in parallel relationship. The plates 56 and 66 extend downward below the track assembly 49 and a pin 65 is inserted therethrough and retained in a pair of aligned openings. The pin 65 rotatably connects the end of the rod 47 of the extension cylinder 45 to the trolley 48. A pair of axles 57 and 58 extend through the plates 56 and 66 near the top edges thereof, with the axle 57 being located near the back end of the trolley 48 and the axle 58 being located near its forward end. Rotatably connected to the back axle 57 are a pair of trolley pulleys 59 and 60 which are positioned between the plates 56 and 66. Also, a pair of wheels 61 and 62 connect to the ends of the back axle 57 and are retained between the tracks formed by the respective angle irons 54 and 55. The forward axle 58 is similarly connected and includes a pair of trolley pulleys indicated collectively as 63 and a pair of wheels indicated collectively as 64.

The trolley 48 is positioned along the track 49 by the extension cylinder 45. If the rod 47 is retracted, the trolley 48 is pulled inward toward the foot of the boom 20, and if extended, the trolley 48 is pushed outward. In addition, however, the trolley 48 is moved along the track 49 when the boom is either raised or lowered. This results from the lateral displacement of the extension cylinder connection point 46 from the boom pivot axis 23. The position of the trolley 48 on the track 49 is thus dependent not only upon the operation of the extension cylinder 45, but also upon the elevation of the boom 20.

The trolley 48 forms part of a first rope and pulley drive assembly which controls the position of the mid boom section 25 with respect to the base boom section 24. The mid boom section 25 in turn forms part of a second rope and pulley drive assembly which controls the position of the outer boom section 26 with respect to the mid boom section 25. The position of the trolley 48 on the track 49 thus determines the relative positions of the boom sections 24, 25 and 26 and, therefore, determines overall boom reach. In the discussion which follows, the first and second rope and pulley drive systems are described in detail, and as shown in FIG. 4, each is actually two, identical systems which are each capable of supporting the basket 32. However, each of the pairs of components which form the rope and pulley drive systems will be treated as a single component and identified in FIG. 4 with the same reference number.

Referring specifically to FIG. 3, the first rope and pulley drive assembly includes an extension rope 68 having one end securely fastened to an end wall 69 which is welded to the outer end of the track 49. The extension rope 68 extends along the track 49, passes underneath and around the forward trolley pulley 63 and back along the track 49 through an opening formed in the plate 69. The extension rope 68 continues over a guide pulley 70 which is rotatably mounted to a plate 67 directly in front of the end wall 69. It then passes under and around a first boom point pulley 71 which is rotatably connected to the bottom panel of the base boom section 24 at its outer end, and upward through an opening in the bottom panel of the base boom section 24. The rope 68 extends back through the space formed between the bottom panels of the base boom section 24 and intermediate boom section 25 and attaches to an end plate 72 which is welded to the lower end of the mid boom section 25.

A retract rope 73 also connects between the mid boom section 25 and the trolley 48. One end connects to a foot plate 74 which is welded to the end plate 72 on the mid boom section 25, and the retract rope 73 extends back and around a pulley 75 which is journalled to the side panels of the base boom section 24. The rope 73 extends downward through an opening in the bottom panel of the base boom section 24 and passes forward beneath the base boom section 24. An end wall 76 is welded to the inboard end of the track 69 and the retract rope 73 passes forward through an opening formed therein, over and around the rear trolley pulley 60 and back to the end wall 76 where its end is securely fastened.

The first rope and pulley drive system forms a closed loop which includes the trolley 48 and the mid boom section 25. The loop extends nearly the entire length of the base boom section 24 and serves to reverse the direction of operation of the extension cylinder 45. That is, when the rod 47 of the extension cylinder 45 is extended, the trolley 48 slides outward, or forward along the track 49 allowing slack on the extension rope 68 and applying tension to the retract rope 73. As a result, when the trolley 48 is moved outward, the mid boom section 25 moves inward, or is retracted. On the other hand, when the rod 47 is retracted, the trolley 48 moves inward applying tension to the extension rope 68 and extending the mid boom section 25. The same action results when the extension cylinder 45 is locked and the boom is elevated or lowered by the elevation cylinder 38. In other words, the trolley 48 slides outward when the boom 20 is lowered and the intermediate boom section 25 retracts. Boom reach is thus made a function of boom elevation, and the instability which can result when operating the boom at low elevations is reduced by automatically retracting the boom when it is lowered.

The extension and retraction of the outer boom section 26 is controlled by the motion of the mid boom section 25. To accomplish this, a second rope and pulley drive system including an extension rope 80 and a retract rope 81 are used. One end of the extension rope 80 is securely fastened to a closure plate 82 which is welded to and encloses the lower end of the base boom section 24. The extension rope 80 extends forward through an opening in the end plate 72 of the mid boom
section 25 and forward through the cavity formed between the bottom panels of the mid boom section 25 and outer boom section 26. The rope 80 passes over a guide pulley 83 rotatably mounted to the bottom panel of the mid boom section 25 near its outer end, and passes under and around a boom point pulley 84 which is also rotatably mounted to the bottom panel of the mid boom section 25 immediately outward of the guide pulley 83. The extension rope 80 then passes back through the same cavity formed by the bottom panels of the mid and outer boom sections and connects to the bottom wall of the outer boom section 26 at a point 85. One end of the retraction rope 81 also fastens to the outer boom section 26 at a point 86 located at its bottom end. The rope 81 passes back through an opening formed in the end plate 72 of the mid boom section 25 and under and around a boom foot pulley 87 which is rotatably connected to the foot plate 74 on the mid boom section 25. The retraction rope 81 extends forward from the pulley 87 through the cavity formed by the top panels of the base boom section 24 and mid boom section 25 and fastens to the top panel of the base boom section 24 at a point 88 at its outer end.

A loop is thus formed and includes the ropes 80 and 81, base boom section 24, the mid boom section 25 and the outer boom section 26. As a result, when the mid boom section 25 is extended or retracted with respect to the base boom section 24, the outer boom section 26 is simultaneously extended or retracted with respect to the mid boom section 25. For example, as the mid boom section 25 is extended, tension is applied to the extension rope 80 and the connection point 85 is pulled toward the boom point pulley 84 to extend the outer boom section 26. On the other hand, when the mid boom section 25 is retracted, tension is applied to the retraction rope 81 and the distance between the boom foot pulley 87 and the connection point 86 is reduced to retract the outer boom section 26. Thus as the mid boom section 25 is extended and retracted with respect to the base boom section 24, the outer boom section 26 is extended and retracted a corresponding amount to provide a telescopic action.

It should be apparent to those skilled in the art that numerous variations can be made from the specific rope and pulley drive systems disclosed herein. For example, the extension ropes 68 and retraction ropes 73 may be fastened directly to the trolley 48 instead of passing around the trolley pulleys 60 and 63. In the preferred embodiment described above, the trolley pulleys 60 and 63 are included to provide a displacement gain of two and to thus magnify by a factor of two the change in boom reach with respect to a change in boom elevation. The reduction in boom reach with respect to changes in boom elevation is doubled to insure that stability is improved at all boom orientations. The displacement gain may not be required in some applications, or in other applications it may need to be increased to provide greater alterations of boom reach.

I claim:

1. In an extensible boom having a plurality of boom sections including a base boom section which is rotatably connected to a turret for pivotal motion in a vertical plane about a pivot axis, and an elevation cylinder connected to said turret and said base boom section to control the elevation of said boom, the improvement comprising:

   an extension cylinder having one end connected to said turret at a point which is laterally spaced a substantial distance from said pivot axis;

   a trolley slidably connected to said base boom section for motion along the lengthwise dimension thereof and connected to the other end of said extension cylinder;

   a second boom section slidably mounted to the base boom section for telescopic motion between a retracted position in which the boom reach is minimal and an extended position in which the boom reach is at a maximum; and

   extension drive means connecting said trolley with said second boom section to alter the reach of said boom by sliding said second boom section with respect to said base boom section in response to the sliding motion of said trolley.

2. The extensible boom as recited in claim 1 in which said extension drive means includes a rope and pulleys which form a loop that contains the trolley and said second boom section, and wherein said second boom section slides outward away from said pivot axis to increase boom reach when said trolley slides inward toward said pivot axis and said second boom section slides inward toward said pivot axis to reduce boom reach when said trolley slides outward away from said pivot axis.

3. The extensible boom as recited in claim 2 in which said trolley is slidably retained to said base boom section by a track which is fastened to the underside of said base boom section.

4. In an extensible boom having a plurality of boom sections including a base boom section which is rotatably connected to a turret for pivotal motion in a vertical plane about a pivot axis, and an elevation cylinder connected to said turret and said base boom section to control the elevation of said boom, the improvement comprising:

   an extension cylinder having one end connected to said turret at a point which is laterally spaced a substantial distance from said pivot axis;

   a trolley slidably connected to said base boom section and rotatably connected to the other end of said extension cylinder; and

   extension drive means connecting said trolley with a second boom section to alter the reach of said boom in response to the sliding motion of said trolley, said extension drive means including:

   a boom point pulley rotatably connected to said base boom section near its outer end;

   a boom foot pulley rotatably connected to said base boom section near its outer end;

   an extension rope having one end connected to said base boom section and its other end connected to said second boom section, said extension rope extending around one of said trolley pulleys and around said boom point pulley; and

   a retraction rope having one end connected to said base boom section and its other end connected to said second boom section, said retraction rope passing around the other of said trolley pulleys and around said boom foot pulley.

5. The extensible boom as recited in claim 4 in which said boom includes a third boom section slidably connected to said second boom section for telescopic motion and said extension drive means includes a second rope and pulley drive which connects to each of said
three boom sections and which is responsive to the position of said second boom section with respect to said base boom section to position said third boom section with respect to said second boom section, such that when the second boom section is extended from said base boom section, said third boom section is extended a corresponding amount from said second boom section.

6. In an extensible boom mounted at one end to a turret for pivotal motion in a vertical plane, said boom having a plurality of boom sections which are slidably mounted to one another for telescopic motion between a retracted position and an extended position, and having means for elevating and lowering said boom in said vertical plane, the improvement therein comprising extension means for automatically altering boom reach in response to changes in elevation, said extension means including:

an extension cylinder having one end connected to said turret at a point which is laterally spaced a substantial distance from the point at which said boom pivotally connects to said turret;

a trolley slidably mounted to the innermost boom section for motion along the lengthwise dimension of said boom, said trolley being coupled to the other end of said extension cylinder for operation thereby; and

rope and pulley drive means which couple the trolley with an outer boom section to impart a sliding motion thereto with respect to said inner boom section when said trolley slides with respect to said inner boom section, and wherein the trolley slides with respect to the inner boom section when said elevating means is operated to retract said outer boom section when said boom is lowered and to extend said outer boom section when said boom is elevated.

7. The improvement as recited in claim 6 in which said rope and pulley drive means provides a displacement gain of more than one to slide said outer boom section a proportionately greater distance than the trolley slides.