(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199867056 B2
(10) Patent No. 732371

(54) Title

A biasing device for an agricultural sprayer

(51)[6] International Patent Classification(s)
B05B 015/06 A01B 073/06

(21) Application No: 199867056

(22) Application Date: 1998.05.18

(30) Priority Data

(31) Number	(32) Date	(33) Country
0586/97	1997.05.22	DK

(43) Publication Date : 1998.11.26
(43) Publication Journal Date : 1998.11.26
(44) Accepted Journal Date : 2001.04.26

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(56) Related Art

US 4044952
GB 1098939

ABSTRACT

The invention relates to a biasing mechanism for resilient attachment in the spraying position of the outer boom section (30) in a boom structure (1), supported by a support frame (2), for an agricultural sprayer, said boom structure (1) comprising boom sections (10, 20, 30) mutually pivotable about vertical axes (45) at linkages (40, 40'), said biasing mechanism comprising a tensile force absorbing wire (60) which is biased by an elastic biasing element (58) at its first end, and which, at its second end, applies a turning moment to the linkage (40) at an outer boom section (30), said turning moment trying to maintain the outer boom section (30) in the spraying position,

said biasing mechanism being characterized in

- that one end of the wire (60) is connected with a force transferring means (50), said force transferring means being so adapted that the tensile force F_w in the wire applies to the linkage (40) at the outer boom section (30) a maximum turning moment in the spraying position and a reduced turning moment in positions where the outer boom section (30) and the inner boom section (10, 20) are pivoted with respect to each other ($\beta > 0$).

P/00/0011
Regulation 3.2

AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title:	**A BIASING DEVICE FOR AN AGRICULTURAL SPRAYER**

The following statement is a full description of this invention, including the best method of performing it known to us

A biasing mechanism for an agricultural sprayer

The present invention relates to a biasing mechanism for resilient attachment in the spraying position of the outer boom section of a boom structure, supported by a support frame, for an agricultural sprayer, said boom structure comprising boom sections mutually pivotable about vertical axes at linkages, said biasing mechanism comprising a tensile force absorbing wire which is biased by an elastic biasing element at its first end, and which, at its second end, applies a turning moment to the linkage at an outer boom section, said turning moment trying to hold the outer boom section in the spraying position.

Agricultural sprayers for use in the treatment of fields and other areas usually comprise a boom structure with foldable boom sections arranged on their respective sides of a central boom section, which may be mounted on a tractor or on a separate trailer which may be coupled to a tractor. Each of the foldable boom sections, which are normally constructed as a lattice structure, carries a plurality of nozzles to which spray liquid is fed via hoses from one or more spray containers arranged on the tractor or the trailer, said spray liquid being optionally diluted with water from a water container mounted in a corresponding manner. Each foldable boom section consists of a plurality of, normally two, separate boom sections connected with each other in a folding link, the inner boom section of which being articulated to said central boom section. In the spraying position, the boom sections extend in extension of each other and are positively secured in this position. During transport of the agricultural sprayer, the boom sections are folded together and are pivoted to a compact position in parallel with the direction of travel.

To reduce the amount of work and time it takes to spray a given area, boom structures of quite considerable lengths have been developed through the years, whereby a large area on each side of the tractor can be treated with a single forward movement of the agricultural sprayer. To allow for uneven terrain it has therefore been necessary to incorporate a certain resilience of the outer ends of the boom sections to avoid damage if an outer end strikes the ground or an obstacle during the travel and is thereby affected by a horizontal collision force directed oppositely to the travelling direction of the agricultural sprayer. This resilience is of considerable importance, because the inner boom section of the boom sections is locked, e.g. hydraulically, in the extended position.

The described resilience of the outer ends of the two boom sections has been provided by means of a biasing mechanism as stated initially, where the actual folding link at the outer boom section has been made resilient, as the outer boom section, when affected by a collision force, is capable of pivoting with respect to the inner boom section to a position which may be parallel with the direction of travel. The known biasing mechanism uses a biasing element in the form of strong tension springs arranged on the central boom section, and these tension springs are connected with the outer boom section via a wire. The positions of the tension springs and the attachment of the wire to the outer boom section cause the outer boom section to be affected by a moment which tries to return it to the starting position, and which is proportional to the deflection. In the spraying position, the outer boom section is secured with a certain bias so that deflection occurs only when the collision force exceeds a certain value. In the deflected state, and when

the collision force ceases, the spring bias built up will be released, and the outer boom section swings back at a great rate. As the folding link comprises locking means preventing the outer boom section from pivoting in the opposite direction past the spraying position, the great velocity of the outer boom section in the return movement gives rise to considerable stresses when the spraying position is reached again. These stresses propagate into the central boom section, which causes problems, inter alia because the entire agricultural sprayer must be dimensioned relatively strongly in view of the maximum stresses caused by the return movement.

The object of the present invention is to provide a simpler and less expensive boom structure in view of the problems mentioned above. This is achieved in that an end of the wire is connected with a force transferring means, said force transferring means being so adapted that the tensile force F_w in the wire applies to the linkage at the outer boom section a maximum turning moment in the spraying position and a reduced turning moment in positions in which the outer and inner boom sections are pivoted with respect to each other ($\beta > 0$). The outer boom section is thereby affected in an expedient manner by a biasing moment, but the boom section will apply smaller forces to the rest of the boom structure in the return movement after a deflection. The reduced turning moment moreover ensures that the agricultural sprayer and thereby also the tractor are only subjected to modest forces when driving past the obstacle which gives rise to the

deflection of the boom section.

According to the present invention there is provided a biasing mechanism for resilient attachment in the spraying position of the outer boom section of a boom structure, supported by a support frame, for an agricultural sprayer, said boom structure comprising boom sections mutually pivotable about vertical axes at linkages, said biasing mechanism comprising a tensile force absorbing wire which is biased by an elastic biasing element at its first end, and which, at its second end, applies a turning moment to the linkage at an outer boom section, said turning moment trying to hold the outer boom section in the spraying position, characterized in:

that one end of the wire is connected with a force transferring means, said force transferring means being so adapted that the tensile force F_w in the wire applies to the linkage at the outer boom section a maximum turning moment in the spraying position whereby the outer boom section is substantially co-extensive with an inner boom section and a reduced turning moment in positions in which the outer boom section and inner boom section define an angle therebetween due to a force subjected to the outer boom section.

According to a particularly advantageous embodiment, the force transferring means and the biasing element are mounted on an inner boom section, preferably on a central boom section mounted on the support frame, or on the sup-

port frame of the boom structure, and the wire is firmly connected with the outer boom section at its second end. The stresses can hereby be absorbed in a simple manner by the boom structure in the ordinarily strongly dimensioned areas of the boom structure where it is suspended on the tractor or on a trailer.

It is preferred that, in a particularly simple manner, the force transferring means can consist of a pivotally mounted force transferring arm having a first force application point for the biasing element and a second force application point for the wire, whereby moment equilibrium of the force transferring arm ensures that said turning moment can decrease from the maximum turning moment to the reduced turning moment. The biasing element is moreover advantageously formed by a spring, preferably a torsional spring.

According to the invention, the linkage at the outer boom section may comprise a substantially circularly cylindrical pipe or disc-shaped element, which is arranged around the axis of rotation of the linkage and substantially perpendicularly to it, and which pivots about said axis upon pivoting of the boom sections with respect to each other. The tensile force absorbing wire is secured to the pipe or the disc-shaped element to be wound on to or off the element upon said pivoting. The axis of the pipe or the element may advantageously be coincident with the axis of rotation. The wire may hereby be dimensioned to a maximum tensile force which corresponds to the bias in the spraying position, and which does not increase upon the deflection of the outer boom section.

In a further embodiment, the agricultural sprayer preferably comprises an additional tensile force absorbing wire, which is connected at its first end with the link-

age at the outer boom section, and which is connected at its second end with a boom section mounted on the support frame or with the support frame, whereby the tensile force F_w in said additional wire applies a turning moment to the linkage at the outer boom section upon pivoting of the inner boom section about its vertical axis from the spraying position to a transport position. When the additional wire is secured at a distance from the axis of rotation of the inner boom section, the wire is subjected to a tension when the boom structure is pivoted to the transport position. This tension causes application of a moment to the outer boom section which pivots to a position in parallel with the inner boom section, while the additional wire is wound off the pipe or the disc-shaped element.

A preferred embodiment of the invention will be described more fully below with reference to the drawing. In the drawing:

fig. 1a shows a section of an agricultural sprayer with an embodiment of the mechanism according to the invention, seen in perspective and in the deflected position,

fig. 1b shows the agricultural sprayer of fig. 1a, seen in the spraying position,

fig. 2a shows the agricultural sprayer of fig. 1a, seen from above,

fig. 2b shows the linkage at the outer boom section, seen in the direction of the arrow 2B in fig. 1a,

fig. 3a shows a detailed view of the mechanism according to the invention where the outer boom section is deflected,

fig. 3b shows a detailed view of the mechanism according to the invention where the outer boom section is in the spraying position.

Figs. 1a and 1b show a section of a boom structure 1 which forms part of an agricultural sprayer for the treatment of fields or the like. The boom structure 1 is intended to be mounted on a support frame 2 which may be mounted on a tractor or on a trailer intended to be coupled to a tractor. The agricultural sprayer additionally comprises one or more containers (not shown) for spray and pumps for feeding the spray via hoses to outlet nozzles arranged along the boom structure 1.

As will appear, the boom structure is composed of a plurality of boom sections 10, 20, 30, of which a central boom section 10 is intended to be connected with the support frame 2, e.g. via a pivot joint 5 having a horizontal axis of rotation or in another conventional manner. The drawing shows two boom sections 20, 30 arranged to the left of the central boom section 10, but it will be appreciated that the boom structure conventionally comprises a corresponding plurality of boom sections which extend on the other side of the central boom section 10. The boom sections 10, 20, 30 are connected with each other by means of pivot joints 40, 40' in an ordinary manner, so that the boom sections 20, 30 on each side of the central boom section 10 may be folded together as indicated by the arrow P2 to engage each other in a transport position, in which, as indicated by the arrow P1, they are moreover pivoted to a position perpendicular to the central boom section 10.

In use of the agricultural sprayer, as shown in fig. 1b, the boom sections 10, 20, 30 are pivoted out to the

spraying position and extend in extension of each other in this position. The inner pivot joint 40' between the boom section 20 and the central boom section 10 is locked by means of a hydraulic actuator 3, while the pivot joint 40 between the outer boom section 30 and the boom section 20 is controlled by means of the mechanism according to the present invention, which will be described in detail below.

In the spraying position, the agricultural sprayer is moved forwards in a direction indicated by the arrow F in fig. 1b, with the boom structure at a certain height above the surface to be sprayed. Driving on uneven terrain or past an obstacle may cause the outer ends of the boom structure 1, i.e. the outer boom section 30, to strike the surface of the ground in certain situations and to be affected by a considerable horizontal force K in a direction opposite the direction of travel F. In order that this horizontal force does not cause damage, the pivot joint 40 has been made resilient by means of the mechanism according to the invention, thereby allowing the boom section 30 to pivot to a deflected position at an angle β with respect to the boom section 20, as shown in fig. 1a. When the force has diminished, either because the boom structure 1 has pivoted back to a horizontal position or because an obstacle in the field has been passed, the mechanism according to the invention causes the boom section 30 to swing back to the spraying position in extension of the boom sections 10 and 20, i.e. in a position in which $\beta = 0$. The pivot joint 40 is adapted to prevent counterclockwise pivoting of the boom section 30 past the spraying position.

Fig. 2 shows a section of the boom structure in fig. 1a, but seen from above. The figure shows the mechanism according to the invention more clearly, which comprises a

force transferring connecting element 60 in the form of an essentially horizontally extending tensile force absorbing wire. The wire 60 is connected with a force transferring arm 50 at its one end, and at its other end it is firmly connected with the outer boom section 30 at a distance form the vertical axis of rotation 45 of the pivot joint 40. The wire 60 extends, as shown, through the open latticework 22 of the boom section 20 from the side of the boom structure 1 which faces the direction of travel F. The attachment of the wire 60 to the boom section 30 is shown in fig. 2b, which also shows the special structure of the pivot joint 40.

Fig. 2b is a more detailed view, seen in the direction of the arrow 2B in fig. 1a, of the pivot joint 40 which connects the outer boom section 30 with the inner boom section 20. As will appear, each boom section 20, 30, at the end, comprises an upper flange 41, 42 and a lower flange 41', 42' which are assembled via upper and lower pin connections 49 and 49', respectively, to establish a vertical axis of rotation 45. The upper and lower flanges 42, 42' of the boom section 30 are interconnected via two vertical stiffening elements 47, 48. A length of a cylindrical pipe 43 is mounted around the two vertical stiffening elements 47, 48. The pipe 43 is preferably arranged with the pipe axis coincident with the axis of rotation 45. The pipe 43 may optionally be formed with a cut peripheral groove for the wires. One end portion 62 of the wire 60 is secured immovably by means of clamps 64 to a small portion of the external surface of the pipe 43, so that, in the spraying position in which $\beta = 0$, the wire 60 is fixed to a tensile force $F_{w,max}$ and thereby transfers a maximum turning moment to the boom section 30. The turning moment will correspond to the tensile force F_w multiplied by the distance A from the axis of rotation 45 to the external surface of the pipe 43 and, as will ap-

pear, will try to maintain the boom section 30 in the spraying position. When the boom section is forced to the deflected position shown in fig. 2b, a portion of the wire 60 is wound on to about half the circumference of the pipe 43, the opposite end of the wire 60 being connected with a movable force transferring arm 50, as described below.

Fig. 3a is a more detailed view of the force transferring arm 50 with which the other end of the wire 60 is connected. The arm 50 is mounted so as to be pivotable about a vertical pin 51 which is secured at each end to a flange 13, 13' secured to a lattice element 12 in the central boom section 10. The force transferring arm 50 can thus pivot in the direction of the arrow P3. At its end opposite the pivot point the arm 50 is provided with a mounting point 52, e.g. a through hole, for the wire 60. In addition, between the pin 51 and the mounting point 52, the force transferring arm 52 is provided with a mounting point 54 for an elastic biasing element 58, which is biased and serves to ensure the resilience of the outer boom section 30 and to ensure that the boom section 30 is returned to the spraying position when the horizontal force, which caused the deflection, ceases. In the example shown, the elastic biasing element 58 is formed by a torsional spring which is mounted around the vertical pin 51, and which has a free end 59 secured to the arm 50 at the point 54. The biasing element 58 is arranged so as to affect the force transferring arm with a spring force trying to pivot the arm 50 in a direction opposite the arrow P3 to a position in which the arm 50 extends at a small angle with respect to the boom sections 10, 20. Pivoting of the arm 50 through an angle α (see fig. 2a) will thus cause the spring 58 to be tensioned. As will be seen, the hydraulic actuator 3 is likewise mounted in connection with the flange 13'.

In figs. 1a, 2a, 2b and 3a, the force transferring arm 50 is shown in a position in which it extends approximately perpendicularly to the boom sections 10, 20. This position corresponds to the deflected position of the boom section 30 shown in fig. 1a in which it is pivoted through an angle β with respect to the boom section 20. In this position, one end portion 62 of the wire 60 is wound on to the pipe 43 in the pivot joint 40, and the opposite end of the wire 60 has moved to the left in fig. 3a. An angular pivoting movement β thus gives rise to a pivoting movement α of the arm 50 in the direction of the arrow P3. The force application point of the wire 60, i.e. the mounting point 52, will be positioned at a distance L perpendicular from the boom section 10, as will appear from fig. 2a, and this distance L will thus vary according to the angular pivoting movement β. Deflection of the boom section 30 thereby generates a tensile force in the wire 60 approximately corresponding to the moment applied by the spring 58 to the arm 50 divided by the distance L.

Fig. 3b shows the force transferring arm 50 in a position corresponding to the boom section 30 being in the normal spraying position, i.e. where the angle $\beta = 0$. In this case, the tensile force in the wire 60 approximately corresponds to the moment of the spring 58 divided by the perpendicular distance L_{min} from the boom section 10. In this position, the biasing element 58 is biased to produce a turning moment on the force transferring arm 50, and moment equilibrium of this arm 50 generates a maximum tensile force $F_{w,max}$ in the wire 60. This tensile force is transferred to the boom section 30 as described above with reference to fig. 2b.

It will be appreciated from the foregoing that suitable construction of the force transferring arm can provide a decreasing tensile force F_w in the wire 60 with an increasing angular pivoting movement β. Selection of L_{min} = 33 mm (corresponding to β = 0°), L_{max} = 155 mm (corresponding to β = 90° and α = 75°), $M_{s,min}$ = 55640 and $M_{s,max}$ = 87740 results in the following values of the tensile force F_w in the wire 60:

$F_w = M_s / L(\beta)$

β = 90°: F_w = 87740 / 155 = 566 N

β = 0°: F_w = 55640 / 33 = 1686 N,

where M_s is the turning moment expressed in Nmm, which is an expression of the spring constant multiplied by the pivoting movement α. As will be seen, a greatest tensile force is obtained for β = 0°, which in turn produces a maximum turning moment on the outer boom section 30. Effective biasing of the outer boom section in the spraying position is obtained hereby.

Folding of the boom structure 1 to the transport position is controlled by means of the hydraulic actuator 3 and an additional tensile force absorbing wire 65. The tensile force absorbing wire 65 extends in its entire length on one side of the boom structure 1 and operates independently of the biasing mechanism in principle. The wire 65 forces the boom structure 30 to pivot along the arrow P2 in fig. 1a when the actuator 3 is operated to move the boom structure to the folded transport position. At its one end, at a distance from the pivot joint 40', the wire 65 is connected with a fixed point 66 (see fig. 2a) on either the central boom section 10, which is mounted on the support frame 2, or on the support frame 2 itself.

The length of the wire 65 is moreover adapted so that the wire 65 is slackened when the boom structure is in the spraying position, and at its other end the wire 65 is connected with the outer boom section 30 at a distance from its axis of rotation 45 in principle in a manner similar to the wire 60. Folding causes simultaneous movement of the boom sections 20, 30 in the direction of the arrows P1 and P2, respectively. The tensioning of the wire 60 by the pivoting along the arrow P2 is balanced by the slackening of the wire 60 which occurs because of the pivoting movement along the arrow P1. It is noted in this connection that the pivot joint 40' of the boom section 20 is closer to the pivot joint 40 than the mounting point 52 of the wire 60 during folding. During folding, part of the bias of the spring 58 is released, as the arm 50 pivots slightly in a direction opposite the direction of the arrow P3 to engage a stop, which may optionally be formed by a vertical lattice element 12 in the central boom section 10.

It is clear to the skilled person that the force transferring arm 50 may be mounted to pivot about e.g. a horizontal axis, and that the biasing element 58 may assume another shape than a torsional spring, e.g. a simple tension spring. The force transferring arm 50 and the biasing element 58 may moreover be mounted at arbitrary places, e.g. on the support frame 2, on the boom section 20 or even on the outer boom section 30. In the latter case, the pipe 43 will be arranged in connection with the flanges 41, 41' of the boom section 20, and it may be necessary to remove the wire 60 when the boom structure is to be folded to the transport position in the direction of the arrow P2. Instead of a cylindrical pipe 43, also a disc-shaped body or the like may be used of course, forming an essentially circular groove to hold the wire 60. Alternatively, the force transferring means

may be constructed as an arm mounted at the outer pivot joint, with the wire 60 connected with the outer end of the arm. In that case, the arm will be mounted so as to protrude approximately perpendicularly from the outer boom section 30 in the spraying position. With the first end of the wire 60 secured to a biasing element 58 arranged on an inner boom section, pivoting of the outer boom section 30 will cause the moment arm of the wire force to be reduced. Suitable selection of the spring constant of the biasing element will also make it possible to obtain declining values for the turning moment.

It is moreover noted that, in principle, it is possible to use a single wire whose ends are secured at the points 52 and 66. In that case, as indicated in dashed line in fig. 2b, the wire will be wound double around the pipe 43, but a portion 62 of the wire will still be fixed against movement along the surface of the pipe 43 by means of clamps 64.

For the purposes of this specification, including the claims, the term "comprising" shall be taken to have the meaning "including".

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A biasing mechanism for resilient attachment in the spraying position of the outer boom section of a boom structure, supported by a support frame, for an agricultural sprayer, said boom structure comprising boom sections mutually pivotable about vertical axes at linkages, said biasing mechanism comprising a tensile force absorbing wire which is biased by an elastic biasing element at its first end, and which, at its second end, applies a turning moment to the linkage at an outer boom section, said turning moment trying to hold the outer boom section in the spraying position, characterized in:

that one end of the wire is connected with a force transferring means, said force transferring means being so adapted that the tensile force F_w in the wire applies to the linkage at the outer boom section a maximum turning moment in the spraying position whereby the outer boom section is substantially co-extensive with an inner boom section and a reduced turning moment in positions in which the outer boom section and inner boom section define an angle therebetween due to a force subjected to the outer boom section.

2. A biasing mechanism according to claim 1, characterized in:

that the force transferring means and the biasing element are mounted on said inner boom section, preferably on a central boom section mounted on the support frame, or on the support frame of the boom structure, and

that the wire is firmly connected with the outer boom section at its second end.

3. A biasing mechanism according to claim 1 or claim 2, characterized in:
that the force transferring means is formed by a pivotally mounted force transferring arm having a first force application point for the biasing element and a second force application point for the wire, whereby moment equilibrium of the force transferring arm ensures that said turning moment can decrease from the maximum turning moment to the reduced turning moment.

4. A biasing system according to any one of claims 1 to 3 characterized in that the biasing element is formed by a spring, preferably a torsional spring.

5. A biasing system according to any one of the preceding claims, characterized in that the linkage at the outer boom section comprises a substantially circularly cylindrical pipe or disc-shaped element, which is arranged around the axis of rotation of the linkage and substantially perpendicularly to it, and which pivots about said axis upon pivoting of the boom sections with respect to each other, and
that the tensile force absorbing wire is secured to the pipe or the disc-shaped element to be wound on to or off said element upon said pivoting.

6. A biasing system according to claim 5, characterized in:
that the axis of the pipe or the element is coincident with the axis of rotation.

7. A biasing system according to claim 5 or claim 6, characterized by:
an additional tensile force absorbing wire, which is connected at its first end with the linkage at the outer boom section, and which is connected at its second end with a central boom section mounted on the support frame or with the support frame, whereby the tensile force F_w of the additional wire applies a turning moment to the linkage at the outer boom section upon pivoting of the inner boom section about its vertical axis from the spraying position to a transport position.

8. A biasing mechanism substantially as hereinbefore described with reference to the accompanying drawings.

DATED: 19 February 2001

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67056/98

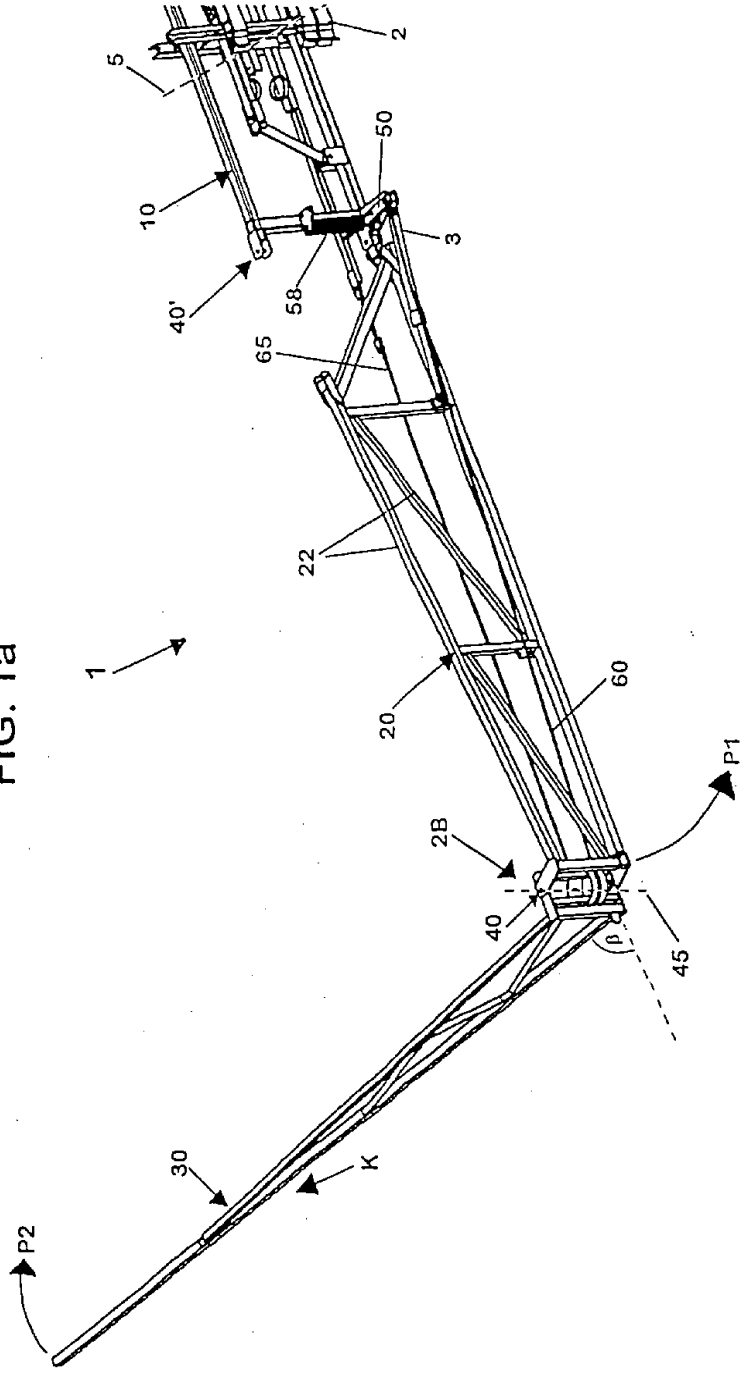

FIG. 1a

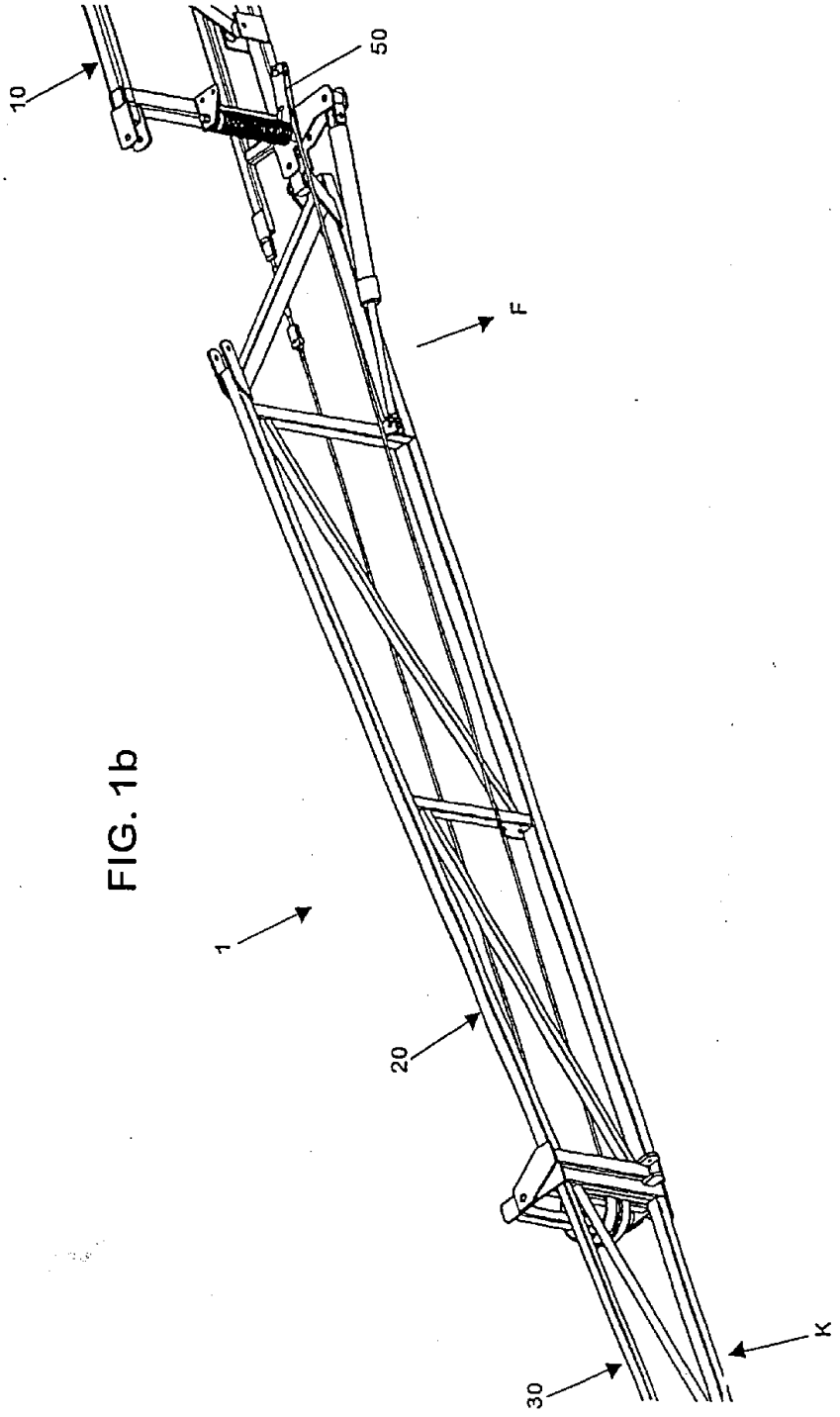

FIG. 1b

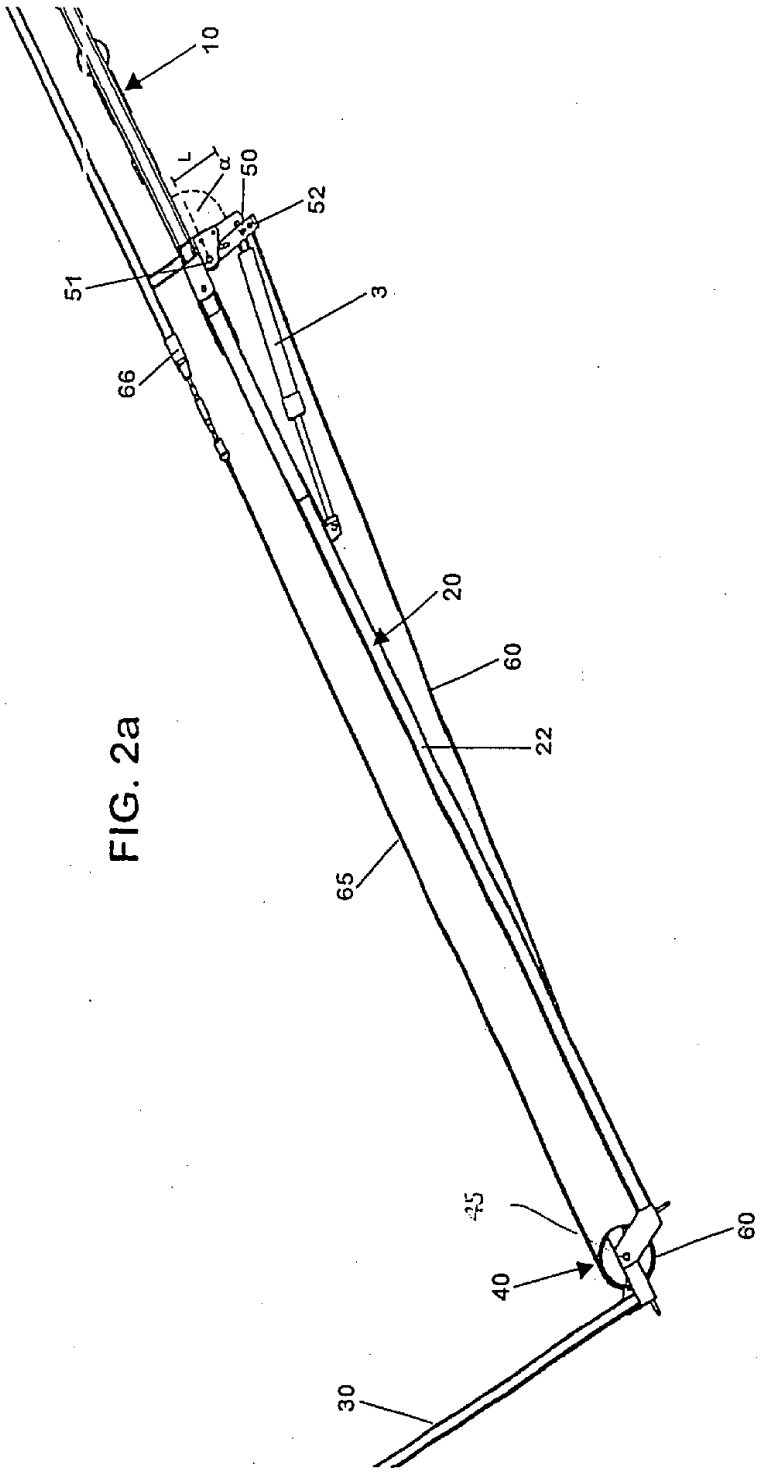

FIG. 2a

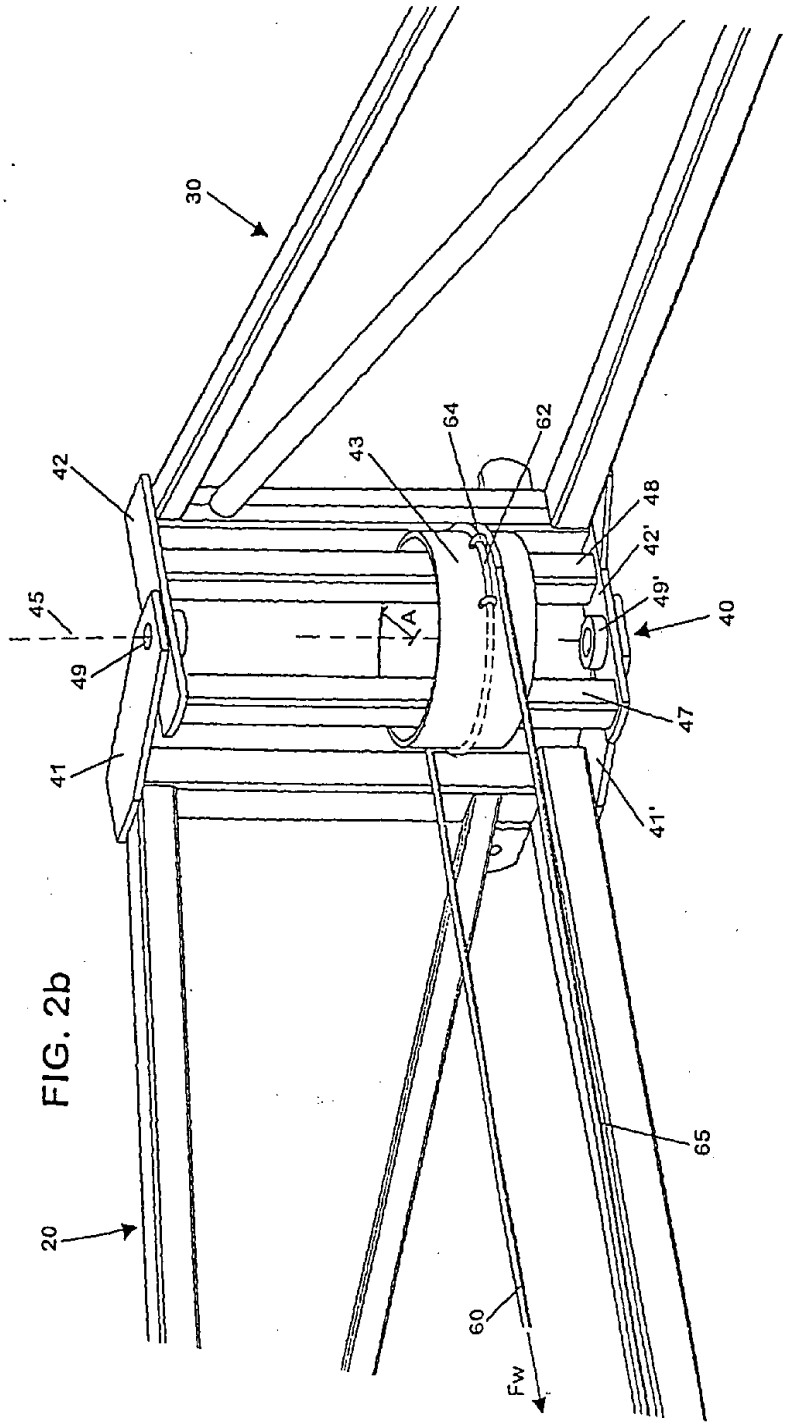

FIG. 2b

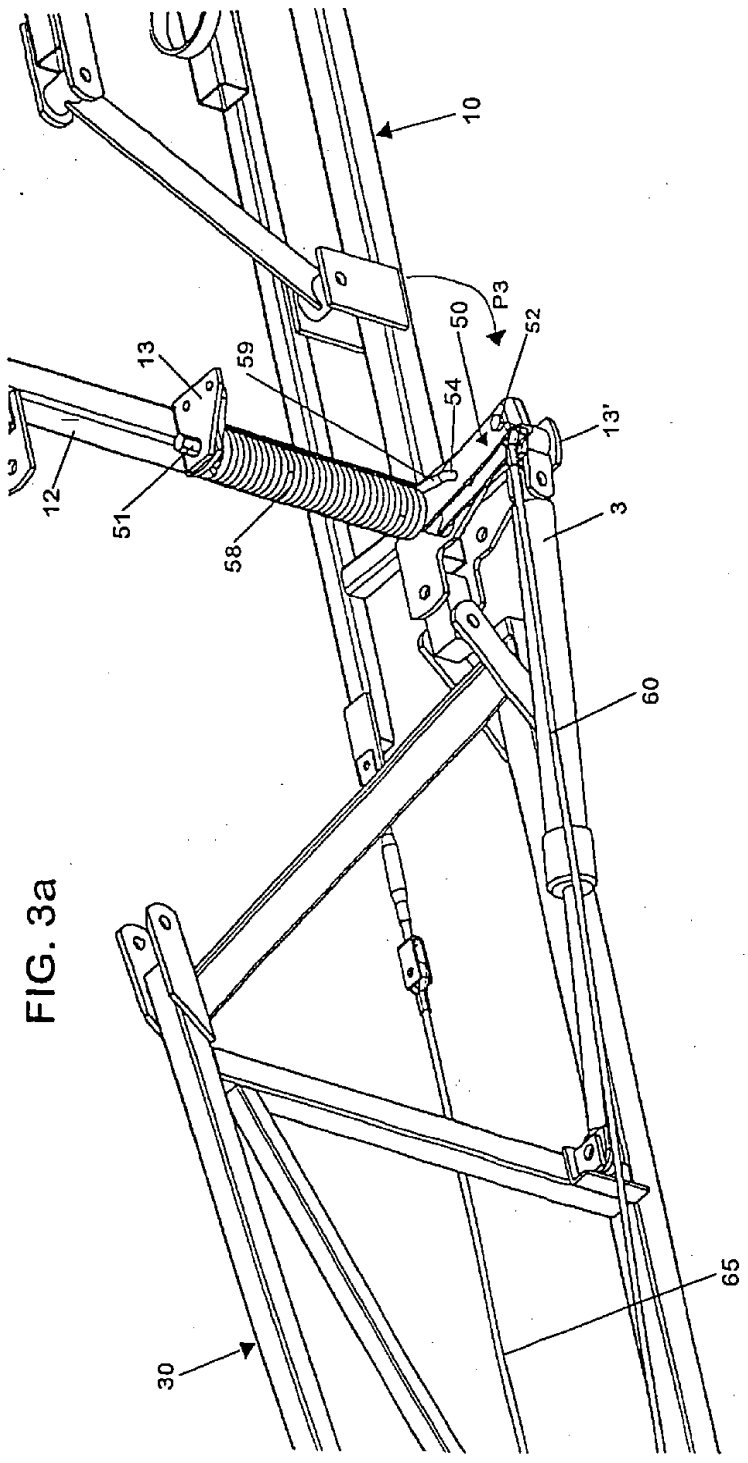

FIG. 3a

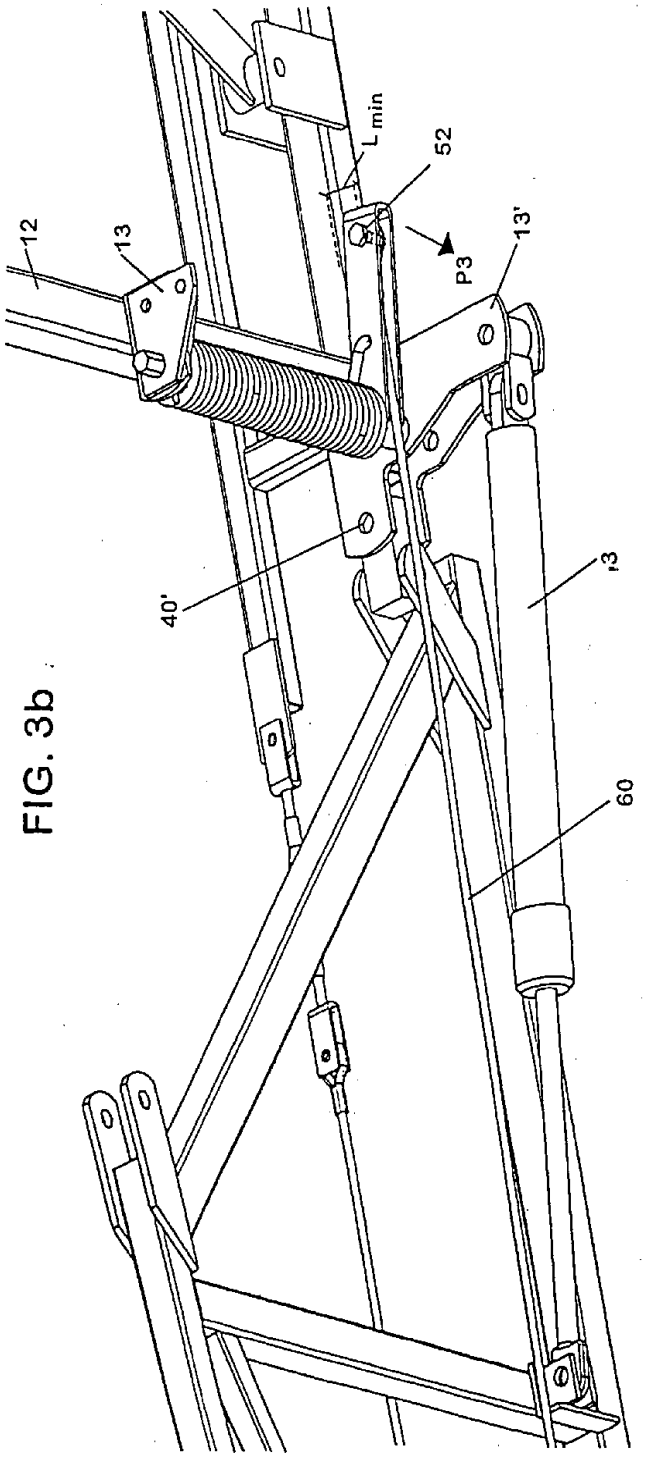

FIG. 3b