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(71) Applicant: **AGCO INTERNATIONAL GMBH**
[CH/CH]; Victor von Bruns Strasse 17, CH8212 Neuhausen
am Rheinfall (CH).

(72) Inventor: **HIDDEMA, Joris Jan**; Roermondskwartier 4,
5971-NL NG Grubbenvorst (NL).

(74) Agent: **AGCO INTELLECTUAL PROPERTY DE-
PARTMENT**; Abbey Park Stoneleigh, Kenilworth CV8
2TQ (GB).

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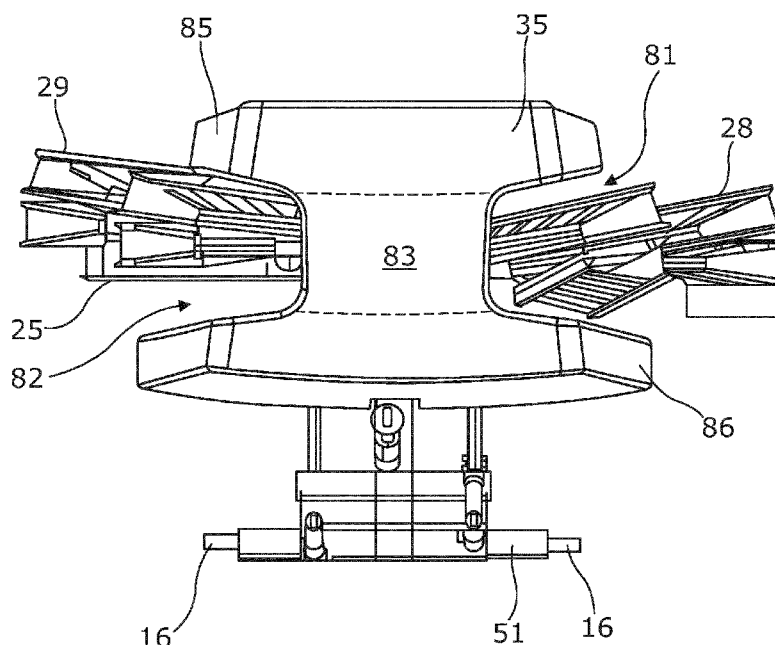


Fig. 5

(57) Abstract: A tractor-mounted agricultural sprayer includes a tank and a pair of foldable boom assemblies carried by a frame (20). Each one of the boom assemblies includes a set of mutually connected boom sections which are configurable in an operating configuration in which the boom sections extend transversely in an unfolded state, and in a transport configuration in which the boom sections are upright in a folded state. The tank has an external profile that comprises two upright recesses which accommodate the boom sections when the boom assemblies are in the transport configuration.



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DESCRIPTION

TRACTOR-MOUNTED AGRICULTURAL CROP SPRAYERTechnical Field

The invention relates to agricultural crop sprayers of the type that are mounted to a tractor three-point linkage and carried across a crop field for dispensing plant protection products (PPP).

Background

Crop sprayers are used extensively in agriculture to apply pesticides and nutrients to crop fields. Such sprayers usually comprise a chassis or frame which carries a tank and a transversely extending boom which may extend up to the order of 24 metres. The boom is typically provided by two side-boom assemblies each having two or more booms sections which are foldable into a transport configuration for moving on public highways.

To cater for different ambient conditions and different crop stages, the boom is typically supported on the chassis in a manner which allows adjustment of the height above the ground and several height adjustable suspension mechanisms to achieve this are well known. Liquid dispensing devices such as nozzles or trailing hoses are mounted to the boom in a spaced relationship for application of the PPPs onto the field. Such a sprayer will also include pipework and plumbing to transfer the PPP from the storage tank to the nozzles.

Agricultural crop sprayers are usually one of three known types: namely mounted, trailed or self-propelled. Mounted sprayers are adapted for mounting to an agricultural tractor three-point linkage wherein the full weight of the sprayer is typically carried upon the tractor's wheels or tracks. Trailed sprayers contain one or more wheeled axles and are towed across crop fields by a towing hitch that is typically connected to a tractor. Self-propelled sprayers include a means of propulsion and a drivers cab and do not require a separate tractor. The invention relates to mounted type sprayers.

One disadvantage of mounted sprayers, compared to trailed sprayers for example, is the significant longitudinal spacing between the spray boom and the rear axle of the

tractor to which the sprayer is mounted. This longitudinal separation results in significant sideways movement of the boom during turns which leads to uneven application of the PPP especially near to the headlands. Furthermore, the continued trend for longer booms add weight to the overall boom structure. When positioned at a distance behind the rear axle of the tractor the increased weight shifts the centre of gravity rearward. To counteract this destabilising effect farmers add counterweights to the front of machine which is in itself detrimental to efforts to minimize soil compaction. As such, farmers requiring larger volume sprayers are driven to employ more complex and expensive sprayers of the trailed or self-propelled type.

Summary of Invention

According to the invention there is provided an agricultural sprayer for mounting to a tractor three-point linkage and for dispensing plant protection products to a crop field, the sprayer comprising a frame having at a front side thereof three-point linkage attachment means, a tank and a pair of foldable boom assemblies carried by the frame, wherein each one of said boom assemblies comprises a plurality of mutually connected boom sections and which are configurable in an operating configuration in which the boom sections extend transversely in an unfolded state, and in a transport configuration in which the boom sections are upright in a folded state, and wherein the tank has an external profile that comprises two upright recesses which accommodate the boom sections when the boom assemblies are in the transport configuration.

By providing recesses in the profile of the tank, the boom can be accommodated forwardly of the rearmost extent of the tank. The boom is advantageously carried significantly closer to the rear axle of the tractor, thus reducing horizontal boom movement during turns and bringing the centre of gravity of the sprayer closer to the tractor. The invention delivers improved evenness in application and a more stable setup which is ultimately safer, especially when operating over inclined areas. Furthermore, the forward shifting of the centre of gravity reduces the need for counterweights on the front of the tractor and thus reduces detrimental soil compaction effects.

The tank may define a continuous receptacle that is preferably continuous throughout and extends both in front and behind the boom frame. The external profile of the tank is therefore designed around the envelope of the boom frame and boom

assemblies so as to optimize the available space and maximize the volume of the receptacle.

In one embodiment the sprayer further comprises a boom frame suspended from the main frame, wherein each boom assembly is pivotally mounted to respective outboard ends of the boom frame. The boom frame is preferably suspended from the main frame by a suspension arm which is pivotally connected to the main frame behind the boom frame.

The boom frame serves to carry the boom which preferably includes first and second boom assemblies which are mounted to respective outboard ends of the boom frame. The weight of the boom assemblies and the boom frame is carried by the suspension arm which pivots with respect to the main frame to raise and lower the boom with respect to the ground.

In a preferred embodiment the main frame comprises first and second vertical plates that are parallel to one another, aligned longitudinally and spaced apart to define a gap therebetween. Conveniently, a suspension arm may reside in the gap, advantageously maintaining a narrow supporting structure around which a storage tank can be shaped. Furthermore, the suspension arm is protected in the gap from damage and corrosion caused by ambient particulates and chemicals. A boom lift actuator may be provided between the suspension arm and the main frame to control raising and lower movement of the boom. The boom lift actuator may, again, be conveniently positioned in the gap thereby optimizing space requirements and protecting the actuator from ambient conditions. The gap is preferably aligned with a central longitudinal axis with respect to the three-point linkage attachment means.

Brief Description of Drawings

Further advantages of the invention will become apparent from reading the following description of specific embodiments with reference to the appended drawings in which:-

Figure 1 is a schematic side view of an agricultural tractor and mounted sprayer in accordance with an embodiment of the invention;

Figure 2 is a plan view of the tractor and sprayer of Figure 1;

Figure 3 is a perspective view of a mounted sprayer in accordance with an example embodiment of the invention showing one boom assembly in an operating configuration and the other boom assembly in a transport configuration;

Figure 4 is a front view of the sprayer of Figure 3 showing both boom assemblies in a transport configuration;

Figure 5 is a plan view of the sprayer of Figure 3 showing both boom assemblies in a transport configuration;

Figure 6 shows part of the boom frame from the sprayer of Figure 3, the boom frame shown with two boom sections mounted thereto and omitting a front panel to reveal the inner workings thereof;

Figure 7 is a front three-quarter perspective view of the main frame and boom frame of the sprayer of Figure 3 showing the latter in a raised position;

Figure 8 shows the same as Figure 7 but with the boom frame in a lowered position;

Figure 9 is a rear three-quarter perspective view of the main frame and the boom frame showing the latter in a raised position;

Figure 10 is an enlarged side view of a spring and damper mechanism associated with one side of the sprayer of Figure 3; and,

Figures 11 and 12 show side and perspective views respectively of the tank of the sprayer of Figure 3 shown in isolation.

Detailed Description of Embodiments

References to relative terms such as front, rear, side, transverse and longitudinal are made with reference to a normal forward direction of travel of the sprayer mounted to the tractor as indicated by arrow F in Figure 2 wherein the longitudinal direction is parallel to the forward direction F.

The basic architecture of a sprayer in accordance with the invention will be described with reference to Figures 1 and 2 before a more detailed embodiment is described

with reference to Figures 3 to 12. However the same reference numerals will be used throughout for both embodiments and with respect to similar components.

With reference to Figures 1 and 2, a sprayer 10 is mounted to a three-point linkage 11 of an agricultural tractor 12. The majority of agricultural tractors available on the market today are fitted with three-point linkages to which various implements can be interchangeably-mounted. Three-point linkages are thus well known and will not be described in detail. However, to summarise, two lower lift arms 13 are typically provided with ball joints (not shown) at their rearmost ends and which receive male transverse pins provided on the implement. A top link 14 provides the third point of attachment and connects between the chassis 12 and a connection point on the implement. The lower lift arms 13 and top link 14 are pivotally mounted at both ends typically by pins and ball joints. The top link 14 is adjustable in length to adjust the pitch of the attached implement and the lower lift arms 13 are raised and lowered by means of hydraulic cylinders (not shown) as required.

Turning briefly to Figures 7, 8 and 9, three-point linkage attachment means are provided on the sprayer 10 in the form of two transversely extending male stubs 16 which serve as attachment points for the lower lift arms 13. Furthermore, the frame is provided with a transverse pair of holes 17 for the receipt of a pin (not shown) for attachment of the top link 14.

The sprayer 10 comprises a frame, designate generally at 20, which is secured to the tractor 12 by the three-point linkage 11. The frame 20 is rigid and includes, in Figures 1 and 2, a front upright post 22 and a rear upright post 24. It should be understood that the frame 20 can be of various different configurations whilst remaining within the scope of the invention. The configuration of frame 20 illustrated in the embodiment of Figures 1 and 2 differs to that of the embodiment of Figures 3 to 12.

A boom frame 25 is suspended from the main frame 20 by a suspension arm 26 which is pivotally connected to the main frame 20 behind the boom frame 25. The suspension arm 26 pivots about a transverse axis by means of the connecting pin 27 which is inserted through holes provided in the frame 20.

The boom frame 25 is shown schematically in Figures 1 and 2 and serves to carry left-hand and right-hand foldable boom assemblies 28,29 (shown only in part in

Figure 2). Together the boom assemblies 28,29 provide a boom which extends in the transverse direction when in the operating configuration as shown in Figure 2. A series of dispensing nozzles 30 are mounted to the underside of the boom assemblies 28,29 each serving to dispense PPPs to a respective area 31 beneath. The central section of the total operating width that is not covered by the extended boom assemblies 28,29 is sprayed by a central set of nozzles 32 that are mounted to the frame 20.

A storage tank 35 (shown only in ghost form in Figures 1 and 2) holds the PPP to be applied is connected to the nozzles 30,32 by a liquid delivery system comprising various pipes and valves as is known in the art. A clean water tank 36 is provided for holding clean rinse water for rinsing the main tank 35. A chemical eductor 38 is provided to facilitate the safe addition of concentrated PPP. The functionality and inter-relationship of the fluid delivery system, nozzles 30,32, clean water tank 36 and chemical eductor 38 is as per known sprayers and is not relevant to the understanding of the invention.

A boom lift actuator in the form of a hydraulic cylinder 40 is connected between the main frame 20 and suspension arm 26 for controlling raising and lowering movement of the boom frame 25 relative to the main frame 20. Although not shown, the hydraulic cylinder 40 is connected hydraulically to the tractor 12 by suitable hydraulic lines. Although a hydraulic cylinder is employed in the illustrated embodiments, it should be appreciated that an electric actuator may be employed instead. In yet another alternative embodiment a manual adjustment mechanism may be provided to control the lift height of the suspension arm 26 and lock with respect to the main frame 20.

A pair of lower stabilizing arms 41,42 are each connected at a forward end to the boom frame 25 at respective transversely-spaced locations and at a rearward end to the main frame 20. The suspension arm 26 and stabilizing arms 41,42 together form a parallel linkage that permits raising and lowering of the boom frame 25 relative to the main frame 20. The function of the stabilizing arms 41,42 will be described in more detail below. However, Figure 1 illustrates well that the stabilizing arms 41,42 together with the suspension arm 26 provide a parallel four-bar linkage between the main frame 20 and boom frame 25. Therefore, as the boom frame 25 is raised and lowered, the pitch thereof is maintained substantially constant.

With reference to Figure 2, arrow Y shows the longitudinal spacing between the rear axle of tractor 12 and the deployed boom assemblies 28,29. By positioning the pivot point for the height adjustment for the boom frame 25 behind the boom frame 25 in accordance with an aspect of the invention the boom is located much closer to the rear axle of tractor 12 than would otherwise be the case. As such any transverse displacement of the boom turning turns is reduced significantly, thereby improving the uniformity of application.

The embodiment illustrated in Figures 3 to 12 will now be described. Like components shared between embodiments will be assigned the same reference signs.

Referring to Figure 3, the left-hand boom assembly 28 and right-hand boom assembly 29 each comprise four mutually-connected boom sections which, within each boom assembly, are pivotally connected to one another by a hinge or the like so as to permit the folding of each boom assembly into a transport configuration. In Figure 3 the right-hand boom assembly 29 is shown in the operating (or deployed) configuration in which the boom sections 29a-d extend in a transverse direction away from the boom frame 25.

First boom section 29a is pivotally mounted to an outboard end of boom frame 25 by a longitudinally aligned hinge 44 which allows the first boom section 29a to pivot upwardly into the transport configuration. A hydraulic actuator 45 is connected between the boom frame 25 and the first boom section 29a to control lifting and lowering as required.

A second boom section 29b is hinged to an outboard end of first boom section 29a by either an upright or longitudinal hinge (not shown). Likewise, third boom section 29c is pivotally connected to an outboard end of second boom section 29b by an upright or longitudinal hinge (not shown). An outer wing or fourth boom section 29d is pivotally connected to the outboard end of third boom section 29c by an upright or longitudinal hinge (not shown). In a preferred embodiment the second, third and fourth boom sections 29b,29c,29d fold about an upright hinge into the transport configuration whilst the inner boom section 29a folds with respect to the boom frame 25 about a longitudinal hinge axis 44 so that the folded boom assembly 29 resides in an upright alignment. Figure 3 shows left-hand boom assembly 28 in the transport position.

It should be appreciated that the respective boom sections can be folded and unfolded via the provision of actuators (not shown) or manually as is also known in the art.

Figure 6 shows the boom frame 25 having a box-like structure with the front panel removed to reveal the inside. The hydraulic cylinder 45 is connected at one end to the boom frame 25 and at the other end to the inner right hand boom section 29a through a cut-out 46 provided in the boom frame 25.

The left-hand boom assembly 28 is mounted to the boom frame 25 and has a like construction albeit mirrored for the opposite side, including a respective boom lift cylinder 47.

The main frame 20 comprises left and right vertical plates 48,49 which are transversely spaced from one another by a separation distance 'z' and arranged in a parallel longitudinal vertical arrangement providing a gap 50 therebetween. It should be appreciated that left-hand vertical plate 48 is omitted from Figures 7 and 8 to reveal the components located in the gap 50.

The frame 20 further comprises a transverse member 51 secured to the vertical plates 48,49 and having lower lift arm stubs 16 provided at the outboard end. Both upright plates 48,49 are also provided with a top-link pin receiving hole 17.

Suspension arm 26 is located in the gap 50 and is pivotally connected to the frame 20 at a rear end by a transverse pin 27 which is held in retaining holes 52 provided in the vertical plates 48,49. At its forward end, the suspension arm 26 is pivotally connected to the boom frame 25 by means of a ball joint 54 provided in association with a vertically-extending boss, or protuberance, 55 which forms part of the boom frame 25. The boss 55 comprises a transverse bore 56 which receives and retains the ball joint 54, wherein a pin 57 inserted through the ball joint 54 secures the boom frame 25 to the suspension arm 26. The ball joint 54 permits the boom frame 25 to pivot with respect to the suspension arm 26 about a horizontal 'pitch' axis and a vertical 'yaw' axis.

Although the ball joint 54 is employed in the described embodiment to permit the pitch and yaw freedom of movement, it should be understood that alternative pivot joints may be employed instead.

With reference to Figures 7 and 8, the boom lift cylinder 40 is connected to the main frame 20 between the vertical plates 48,49 at a lower connection point 59 and to an intermediate position on the suspension arm 26 at an upper connection point 60. An accumulator 62 may be hydraulically connected to cylinder 40 to provide for a cushioning effect to smooth out vertical oscillations caused by transit over uneven terrain. Although not shown, the hydraulic cylinder 40 is hydraulically connected to the tractor 12 to control lifting and lowering of the boom frame 25.

The vertical plates 48,49 each comprise a respective cut-out 63,64 which is generally arcuate in shape and allows the boom frame 25 to extend transversely beyond the gap 50. The vertical dimension of the cut-outs 63,64 is determined by the vertical lift range of the boom frame 25 which is controlled by lift cylinder 40.

The vertical plates 48,49 provide protection for the components located in the gap 50 including the lift cylinder 40 and the suspension arm 26. It should be appreciated however that the main frame 20 may take various different constructions and may vary to the arrangement illustrated.

With reference to Figures 9 and 10, the left-hand stabilizing arm 41 is shown connected between the boom frame 25 and the main frame 20 via a spring and damper mechanism designated generally 70. It should be appreciated that the right-hand stabilizing arm 42 is out of view in Figures 9 and 10 but is arranged in the same way as left-hand stabilizing arm 41 which will be described below.

The spring and damper mechanism 70 comprises a bell crank 72 which is pivotally mounted on the outboard side of vertical plate 48 so as to pivot about a transverse axis provided by pin 73. The bell crank 72 comprises a first limb 74 to which the stabilizing arm 41 is pivotally connected, and a second limb 75 to which a damping cylinder 76 is connected. The damping cylinder 76 is connected at one end to the left-hand vertical plate 48 and at the other end to the second limb 75 of bell crank 72.

First and second springs 78,79 are mounted upon a bracket arrangement 80 which is secured to the upright plate 48, wherein the springs 78,79 abut opposite sides of the

bell crank 72, in particular against the second limb 75. The springs 78,79 may be provided by rubber cushions which are deformable and serve to impart a restoring force upon the bell crank 72 when displaced away from the neutral position shown in Figure 10. Although illustrated as rubber stops, the springs 78,79 may be replaced by alternative forms of biasing devices such as compression springs or the like.

It should be understood that any pitch or yaw of the boom and boom frame 25 is transferred by the stabilizing arms 41,42 to the respective spring and damper mechanisms 70. As such, the spring and damper mechanisms 70 serve to control pitch and yaw movement of the boom frame 25 and prevent excessive oscillations which can lead to damage of the overall structure and/or uneven application during operation.

Turning to the details of tank 35 (Figures 3 to 5, 11 and 12) the external profile comprises two upright recesses when viewed from above, the recesses serving to accommodate at least a portion of the boom assemblies 28,29 when in the transport configuration. The upright recesses 81,82 are located either side of a central narrow portion 83, best seen in Figure 5. The provision of the upright recesses 81,82 allows the folded boom assemblies 28,29 to reside within a narrower envelope in the transport position whilst optimizing the available space both in front and behind the boom assemblies 28,29.

The tank 35 is preferably moulded from a polymeric material and defines a single continuous receptacle for the PPP to be applied. The receptacle extends both in front and behind the boom frame 25 thereby making use of the available space whilst remaining within the transverse and longitudinal envelope which may be limited by local highway legislation and also by the moment imparted on the three-point linkage. A rear portion 85 of the tank 35 extends in the vertical direction from the base of frame 20 (level with transverse member 51) to a height above the frame 20. The rear portion 85 is disposed behind the boom assemblies 28,29 when in the transport and the operating configurations. The central narrow portion of the tank 83 is contiguous with the rear portion 85 and is located over the boom frame 25 at all times. A front portion 86 of the tank 35 is contiguous with central narrow portion 83 and has an associated volume that is disposed entirely above, and in front, of the boom frame 25.

The rear portion 85 includes a central vertical recess 88 which accommodates part of the vertical plates 48,49. Furthermore, the rear portion 85 comprises a widened longitudinal gap 89 to accommodate the spring and damper mechanisms 70.

It should be appreciated that in the embodiment illustrated the majority of the volume of tank 35 is disposed behind the boom assemblies 28,29 and boom frame 25.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the field of agricultural sprayers and component parts thereof and which may be used instead of or in addition to features already described herein.

CLAIMS

1. An agricultural sprayer for mounting to a tractor three-point linkage and for dispensing plant protection products to a crop field, the sprayer comprising a frame having at a front side thereof three-point linkage attachment means, a tank and a pair of foldable boom assemblies carried by the frame, wherein each one of said boom assemblies comprises a plurality of mutually connected boom sections and which are configurable in an operating configuration in which the boom sections extend transversely in an unfolded state, and in a transport configuration in which the boom sections are upright in a folded state, and wherein the tank has an external profile that comprises two upright recesses which accommodate the boom sections when the boom assemblies are in the transport configuration.
2. A sprayer according to Claim 1, wherein the tank defines a continuous receptacle that extends both in front and behind the boom frame.
3. A sprayer according to Claim 1 or 2, further comprising a boom frame suspended from the main frame, wherein each boom assembly is pivotally mounted to respective outboard ends of the boom frame.
4. A sprayer according to Claim 3, wherein the boom frame is suspended from the main frame by a suspension arm which is pivotally connected to the main frame behind the boom frame.
5. A sprayer according to Claim 3 or 4, wherein the tank has a volume, and wherein a majority of the volume is located behind the boom frame.
6. A sprayer according to Claim 4, wherein the main frame comprises first and second vertical plates that are parallel to one another, aligned longitudinally, and spaced apart to define a gap therebetween, and wherein the suspension arm resides in the gap.
7. A sprayer according to Claim 6, wherein the external profile of the tank comprises a central longitudinal recess which accommodates at least a portion of the first and second vertical plates.

8. A sprayer according to Claim 7, wherein the suspension arm is pivotally connected to the main frame behind the tank.

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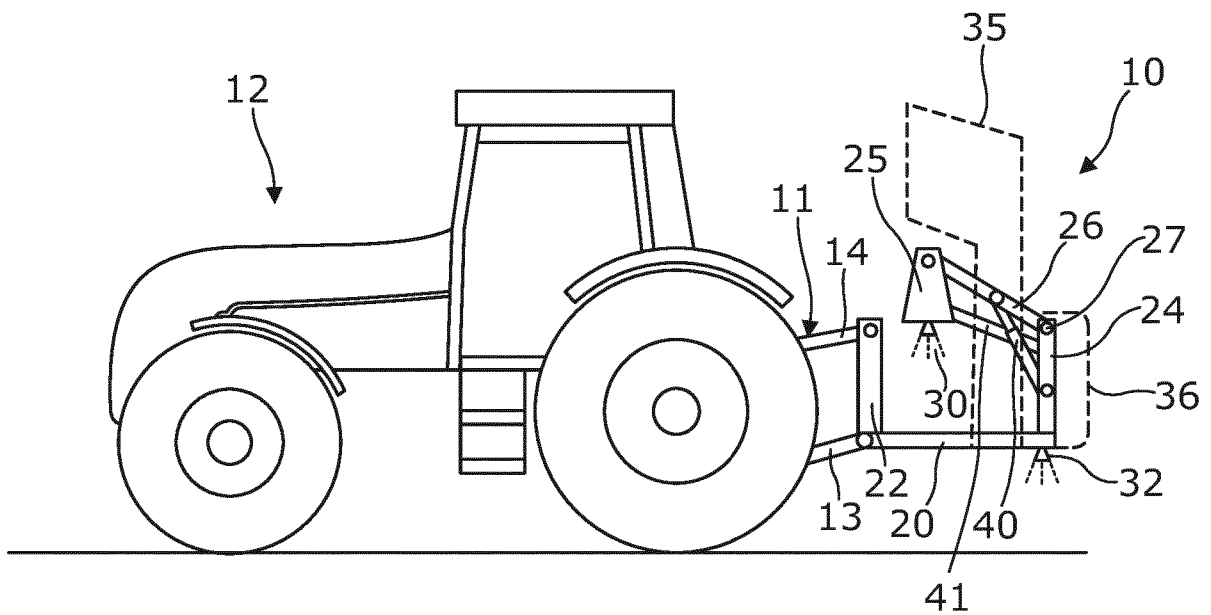


Fig. 1

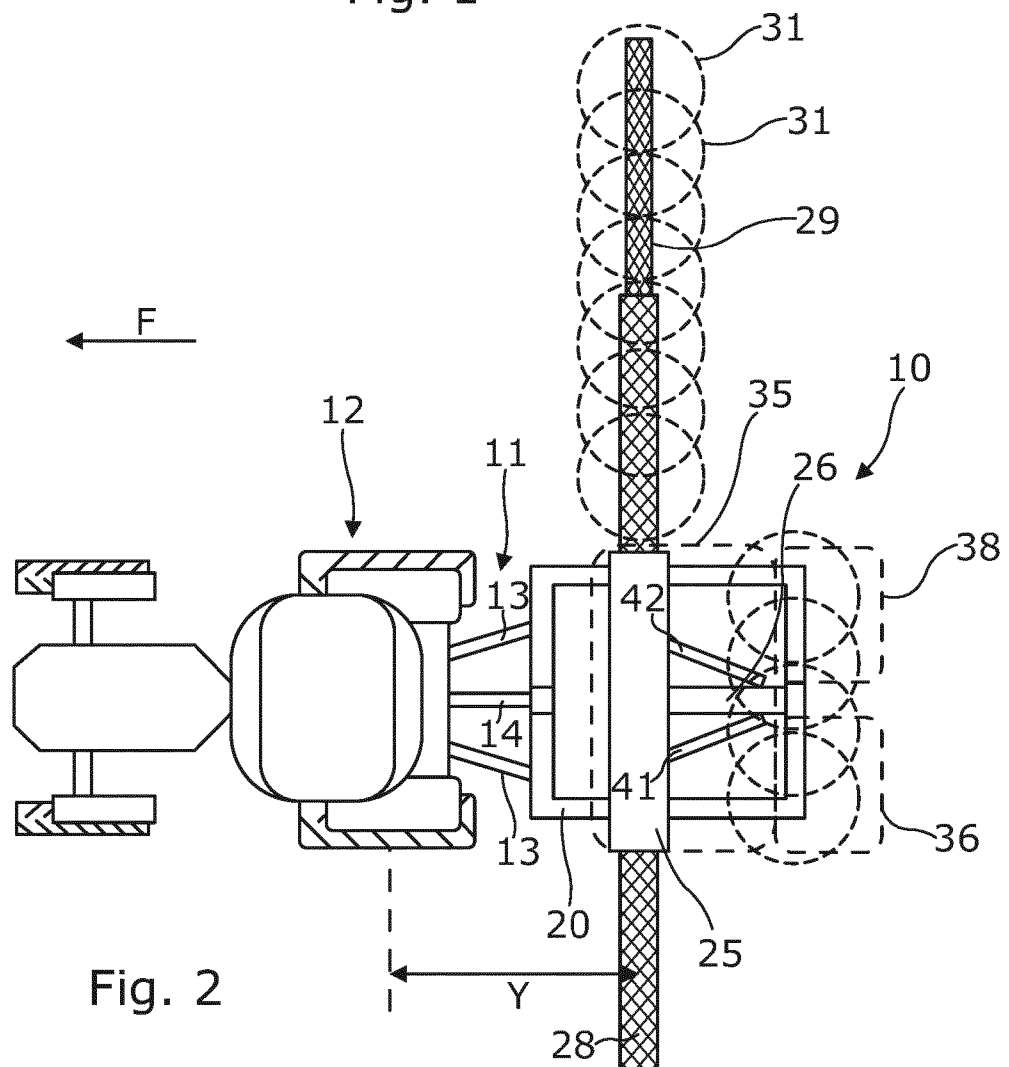


Fig. 2

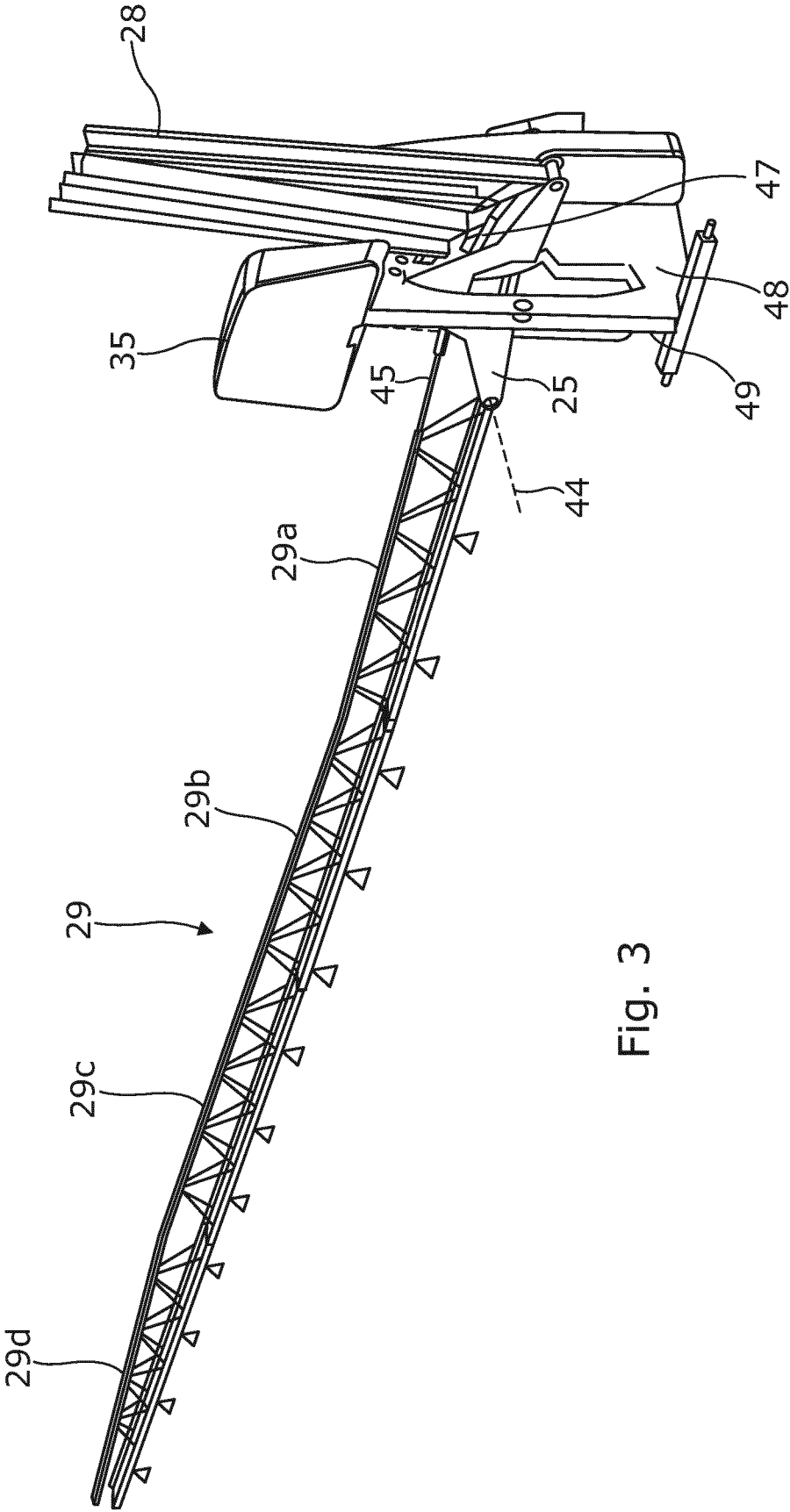


Fig. 3

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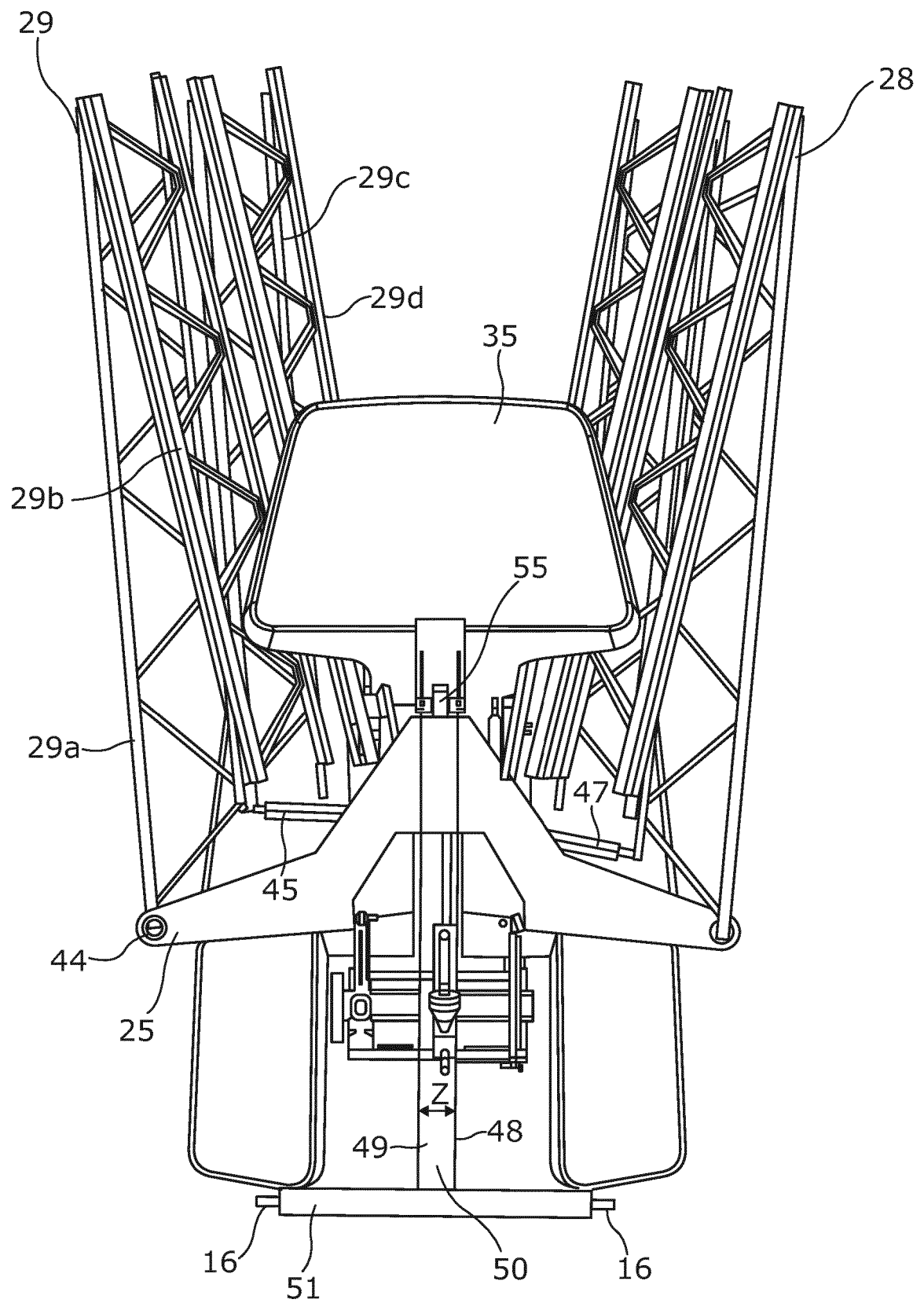


Fig. 4

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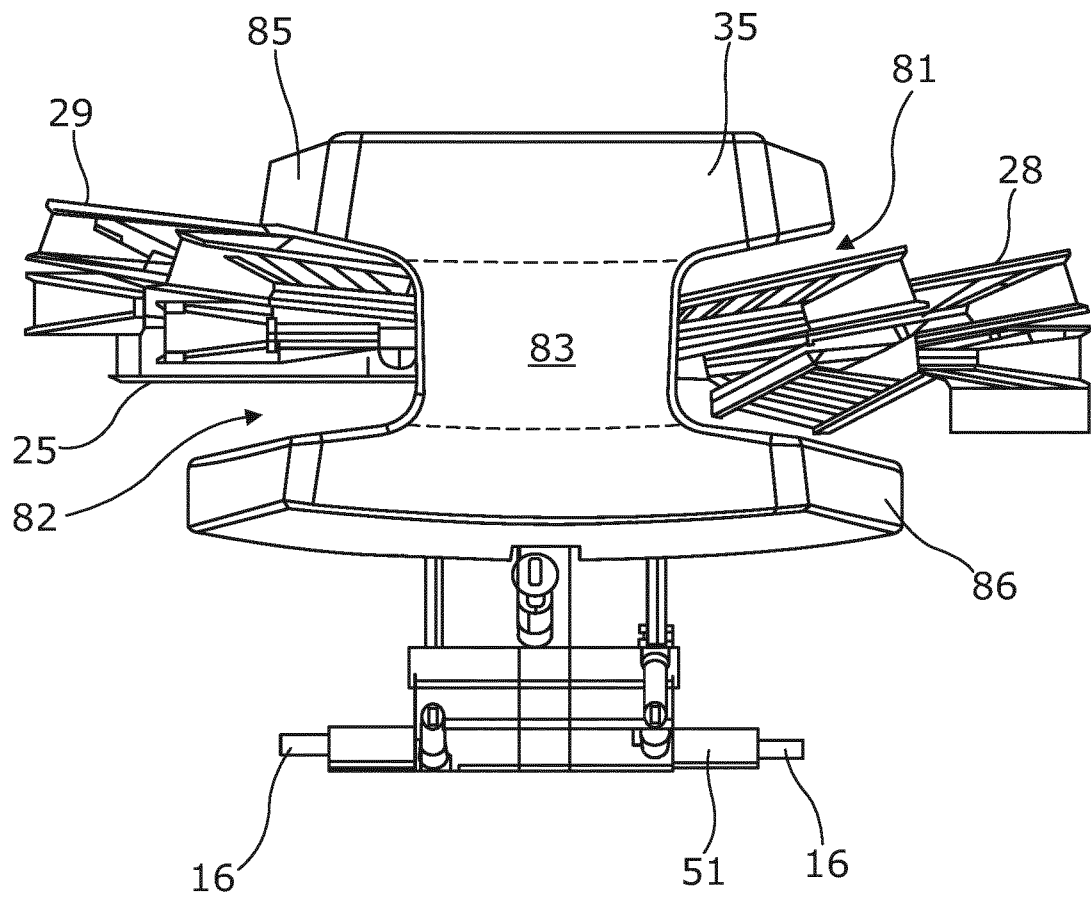


Fig. 5

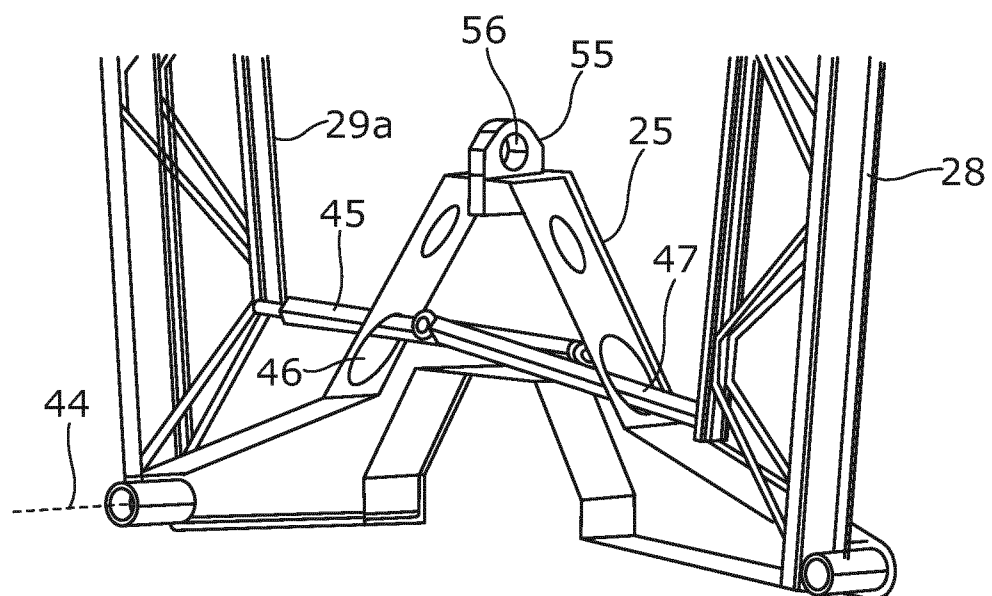


Fig. 6

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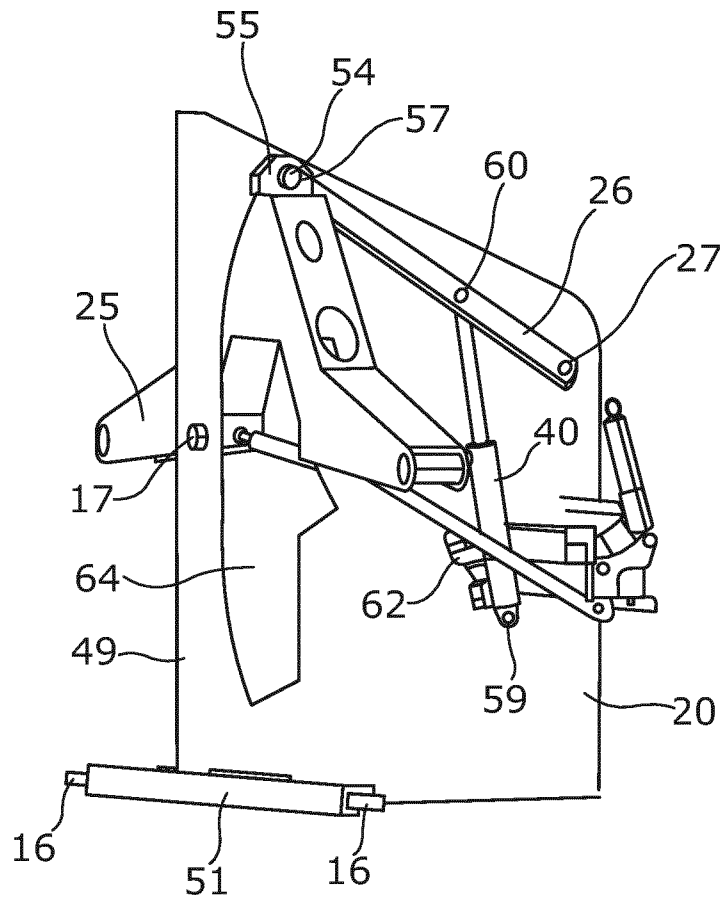


Fig. 7

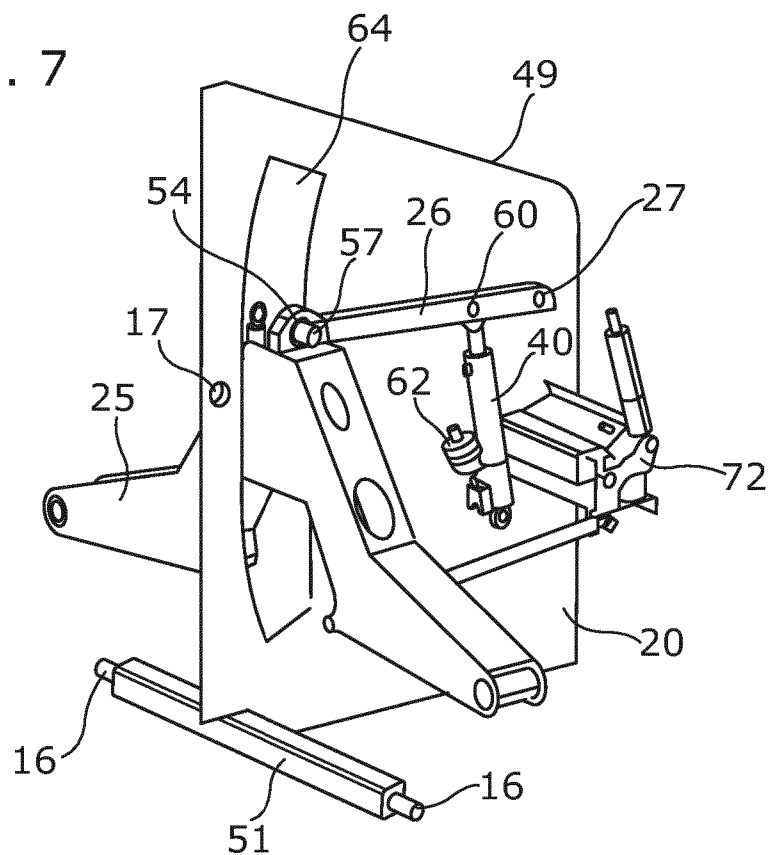


Fig. 8

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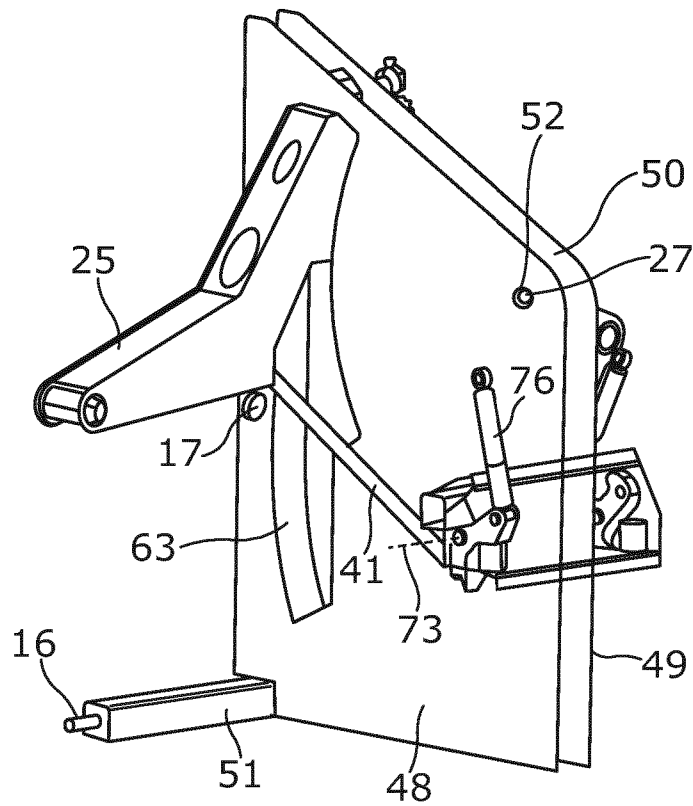


Fig. 9

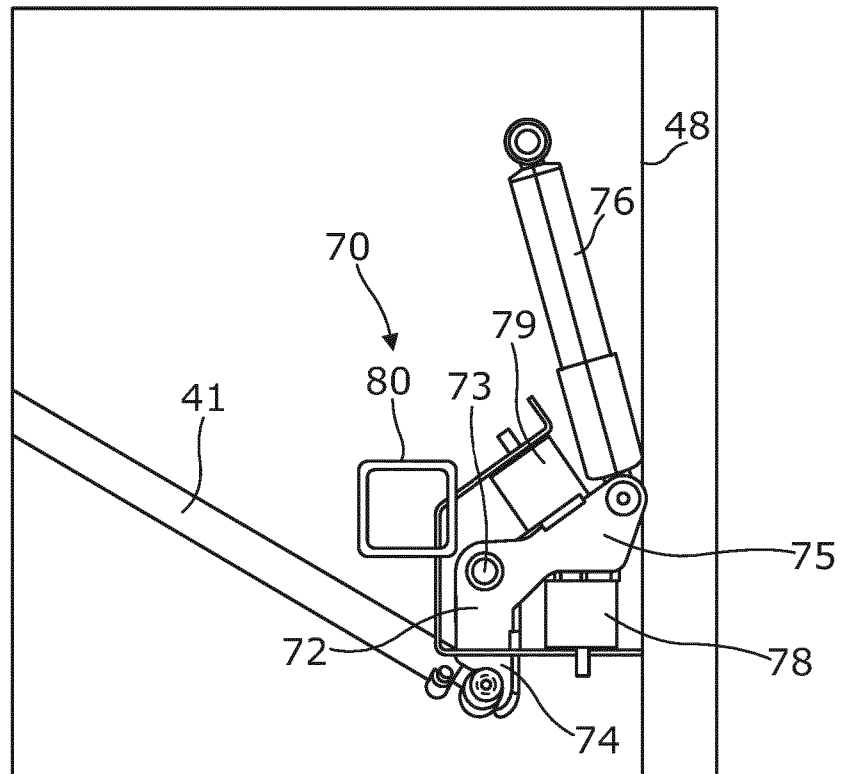
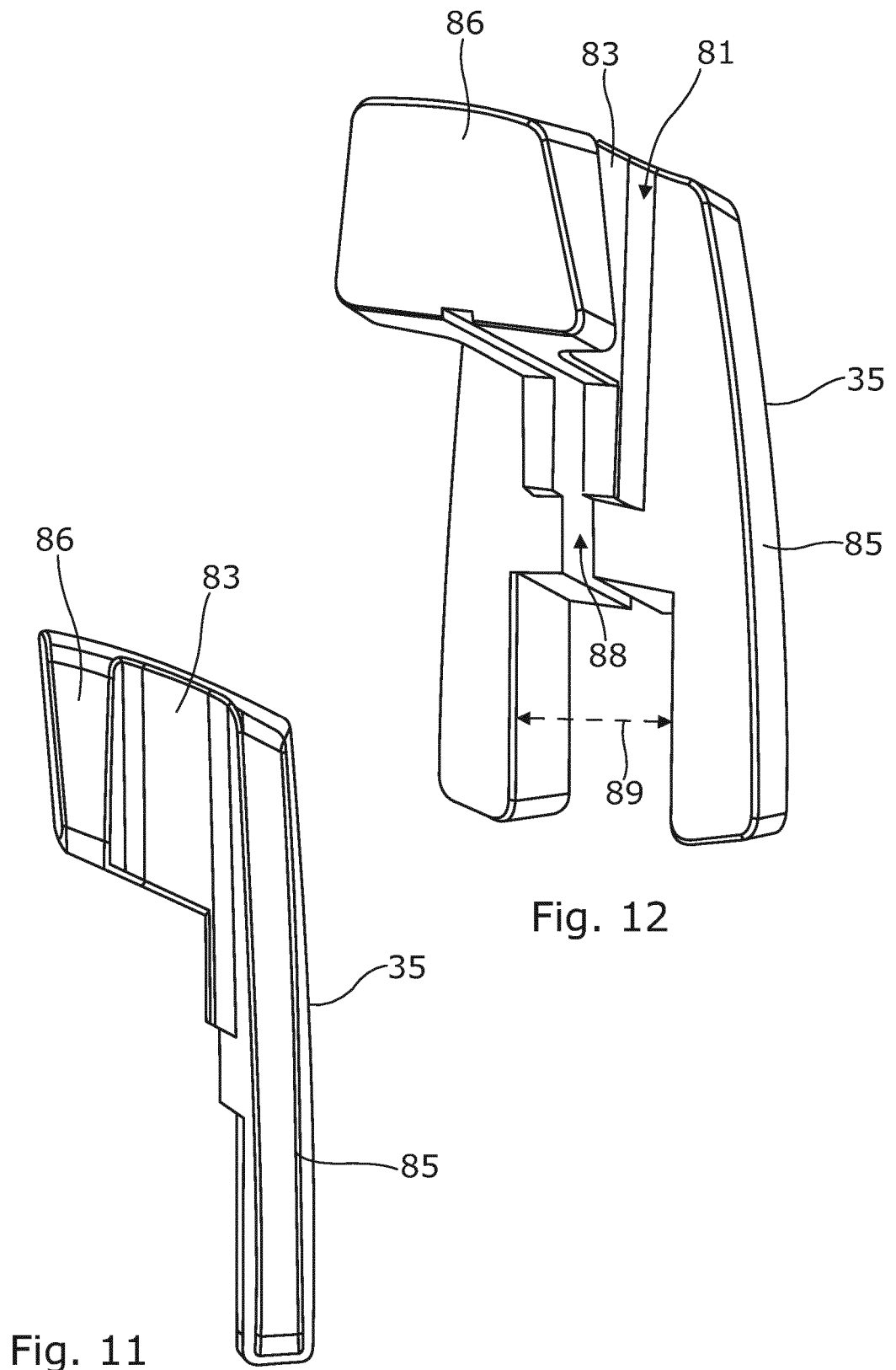


Fig. 10



INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
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ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A01C A01M B60P B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Amazone: "Amazone UF 2002 mounted sprayer", Internet 26 October 2017 (2017-10-26), pages 1-44, XP002788632, Retrieved from the Internet: URL:https://info.amazone.de/DisplayInfo.aspx?id=46203 [retrieved on 2019-02-05]	1,3-5
A	the whole document	2,6-8
A	EP 2 001 287 A2 (KUHN SA [FR]) 17 December 2008 (2008-12-17) paragraph [0010] - paragraph [0030]; claim 9; figures 1-4 ----- -/-	1-8



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

5 February 2019

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20/02/2019

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/078915

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 600 01 132 T2 (EXEL IND EPERNAY [FR]) 2 October 2003 (2003-10-02) page 1, paragraph 2; figures 1-14 page 5, paragraph 3 - page 11, paragraph 1 -----	1-8
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