A boom section (13) for a multi-section boom of an agricultural sprayer is provided. The boom section comprises two upper transverse tubes (31, 32), lower transverse tubes (33), and a plurality of upright members (20) of the same construction and size serving to maintain a spatial relationship the transverse tubes. The transverse tubes extend along the length of the boom section parallel to one another and are each formed from a continuous length of tubular material, preferably steel or aluminium. The upright members each comprise four transverse sleeves which each receive a respective one of the transverse tubes. The sleeves may be accompanied with clamping means to secure the transverse tube held therein.
DESCRIPTION

MODULAR SPRAYER BOOM CONSTRUCTION

The invention relates to agricultural sprayers and particularly to sprayer booms which extend transversely to the direction of travel and serve to support a plurality of application devices such as spray jets.

BACKGROUND

Agricultural sprayers are employed to apply chemicals in liquid form to field and to row crops growing in fields. A sprayer typically comprises a storage tank, a liquid delivery network, and a set of dispensing devices supported on a boom.

Sprayers can be mounted to the linkage of a tractor, towed behind a tractor or provided with an engine so as to be self-propelled. Regardless of the type, the majority of booms are formed from several boom sections which pivot with respect to one another to allow the boom to be folded into a transport position. In the transport position, the sprayer can be moved from field to field and can travel on public highways.

When used for row crops, sprayers follow the same tram lines for each application to minimise the area of crop flattened. To minimise the number of tram lines farmers are turning to increasingly wider booms so as to increase the distance between adjacent tram lines and lower the number of passes required. Today, 40-metre booms are not uncommon and the drive to increase boom width continues.

Longer booms, however, present their own problems not found in shorter booms. The forces exerted on the unsupported lengths of the boom lead to undesirable oscillations and vibrations. Considering also the increased cost of larger booms, farmers and contractors face a play off between accuracy and length. Therefore, OEMs typically offer a range of different booms sizes to cater for the requirements of different customers. This requires the manufacturers to stock a host of differently-sized components leading to large inventories in the factory and long lead times.
SUMMARY OF INVENTION

It is an object of invention to provide a boom construction that can be used for different boom lengths whilst reducing the number of different components required.

It is a further object of the invention to provide a method of manufacturing a boom structure which utilises common components regardless of the length of boom required.

It is yet another object of the invention to provide a simplified method of manufacturing a boom with reduced lead time.

In accordance with a first aspect of the invention there is provide a boom section for a multi-section boom of an agricultural sprayer, the boom section comprising at least three transverse tubes, and a plurality of upright members of the same construction and size serving to maintain a spatial relationship between the transverse tubes, the transverse tubes extending along the length of the boom section parallel to one another and each being formed from a continuous length of tubular material, the upright members each comprising a respective transverse channel for each of the transverse tubes, each channel receiving a respective one of the transverse tubes.

The invention involves the recognition that many booms offered on today's market are tapered inwardly towards the outside of the boom with the aim to reduce weight and stresses. For the boom manufacturer this requires a host of differently sized components as the dimensions of the boom change along its lengths. By providing a boom with upper and lower transverse tubes in a parallel relationship, the upright members which maintain the spatial relationship between the tubes can be common in construction with the same geometry. This presents a significant advantage for the boom manufacturer in a significant reduction of components required.

Furthermore, the use of continuous tubular material allows the manufacturer to cut the tubes to lengths as required. Also the absence of welded joints between the sub sections increases strength and integrity.

The boom section may comprise a pair of lower transverse tubes and a single upper transverse tube located above the lower tubes, the pair of lower tubes being horizontally aligned. Alternatively the boom section may comprise a pair of upper
transverse tubes and a single lower transverse tube located below the upper tubes. More preferably, the boom section comprises a pair of upper transverse tubes and a pair of lower transverse tubes located below the upper tubes.

The upright members preferably further comprise a plurality of clamping means which each prevents movement of a respective one of the transverse tubes through its respective channel. In a preferred arrangement each sleeve can be tightened by a nut and bolt for example so that the channel clamps to the tube. Alternatively, the transverse tubes are secured to the upright members by gluing. In either case, welding is not required. Welded joints have been found to weaken the area around the weld. Failures in the boom structure are often located at or near a welded joint. The use of clamps or glue instead of welding for securing the transverse members to the upright members thus reduces the risk of structural failure.

The boom section preferably further comprises first and second brace members extending diagonally between adjacent upright members. The brace members advantageously provide strength and integrity to the boom structure especially countering twisting forces experienced during folding and unfolding.

Crossing opposing diagonals the first brace member preferably intersects the second brace member at a mid-point between the adjacent upright members. In a preferred arrangement the first brace member is narrower at the point of intersection than the second brace member and passes through an aperture in the second brace member. Preferably, the first and second brace members are secured to one another at said point of intersection, for example by a pin which passes through holes formed in the first and second brace members.

Preferably, the first and second brace members are secured at each end to respective adjacent upright members. Advantageously, this gives a greater degree of freedom for the transverse tubes to flex thus reducing stress points along the length of the boom.

In a preferred arrangement each upright member comprises two lower legs and two upper legs, each leg being integral with a respective one of said sleeves. This gives the upright member a substantially H-shaped construction which may taper towards either the top or bottom. At the end of each leg, one of said sleeves is provided which effectively forms a clamp to receive the transverse tubes.
At least one of the first and second braces preferably comprises, at one end, a pair of jaws, each jaw receiving therein, and being secured to, a respective one of said legs of the upright members. Preferably, the legs of the upright members have a substantially rectangular section which be can be conveniently received in a square jaw provided by the braces.

Preferably the first and second brace members each comprise, at a lower end, a pair of legs each being integral with a respective one of said jaws, the first brace member comprising at an upper end a single leg which is secured between the two upper legs of an upright member, the second brace member comprising at an upper end a pair of legs each including a jaw which receives therein, and is secured to, a respective one of said upper legs of the upright members.

Preferably, a single securing pin passes through holes formed in the jaws of the second brace member, the two upper legs of the upright member and the single leg of the first brace member thus minimising the number of components required.

The transverse tubes are preferably formed from aluminium or steel whilst the upright members and brace members are formed from a composite material. It has been found that composite materials do not provide enough damping when used to form the transverse tubes of a boom and do not handle high frequency oscillations well. Conversely, steel is relatively heavy whilst aluminium is expensive.

Furthermore, composite materials can tolerate tensile forces much better than compressive forces. Therefore, an optimum structure can be accomplished when aluminium or steel are employed for the lower transverse tubes and a composite material is employed for the upper transverse tubes.

Multiple boom sections made in accordance with the invention can be employed on a single machine. Boom sections positioned towards the outside of the overall boom may be formed with smaller upright members compared to the sections employed towards the centre. Pivoting joints may be provided between the adjacent boom sections to allow for folding of the boom into transport mode.
In accordance with a second aspect of the invention there is provided a method of manufacturing a boom section for a multi-section boom of an agricultural sprayer, the method comprising:

- cutting at least three transverse tubes from one or more lengths of tubular material;
- forming a plurality of upright members of the same construction and size and each having at least three parallel channels;
- assembling the transverse tubes in a spaced parallel relationship by inserting the tubes through respective channels in the upright members, wherein two of the tubes are horizontally aligned and two of the tubes are vertically spaced from one another.

In a preferred method of manufacture, diagonal brace members are secured to the upright members before positioning and securing the transverse tubes.

The use of common upright members for a single boom section allows a boom manufacturer to stockpile the upright members before assembly with reduced inventory.

The upright members may further comprise a plurality of clamping means wherein the method further comprises the step of tightening the clamping means to prevent the movement of the transverse tubes through their respective channels. The use of clamping means over welded joints delivers an improved method of manufacture because welded joints have been found to result in regions of structural weakness.

**BRIEF DESCRIPTION OF DRAWINGS**

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

Figure 1 is schematic plan view of a trailed agricultural sprayer;

Figure 2 is a schematic elevation view of a multi-section boom in accordance with a first embodiment of the invention;
Figures 3 to 5 show perspective views of respective boom sections used in the multi-section boom shown in Figure 2;

Figure 6 is a perspective view of an upright member employed in the construction of the boom sections shown in Figures 3 to 5;

Figures 7 and 8 each show respective brace members used in the construction of the boom sections shown in Figures 3 to 5;

Figure 9 is a perspective view of an upright member having an alternative construction; and,

Figure 10 is a perspective view of the upright member of Figure 9 shown with one lower transverse tube and one upper transverse tube in position.

DETAILED DESCRIPTION OF DRAWINGS

With reference to Figure 1, a trailed sprayer 2 comprises a storage tank 3, a drawbar 4 and a multi-section boom 10. The drawing is highly schematic and it should be understood that the means of supporting the boom 10 on the sprayer 2 will be more complex than that shown.

As with known sprayers, the boom 10 is formed from multiple sections which pivot with respect to one another. A central section 13 is mounted to the sprayer. Two intermediate sections 12, 14 are pivotally mounted to respective ends of central section 13 in a known manner. Outer sections 11, 15 are pivotally mounted to the outside ends of intermediate sections 12, 14.

The intermediate sections 12, 14 pivot inwardly in a known manner to reside alongside the storage tank 3 during transport. Outer sections 11, 15 pivot in the opposite direction so as to fold back against intermediate sections 12, 14 when in the transport position.

The boom 10 supports a number of dispensing devices represented in Figures 1 and 2 at 16. It should be understood that the figures are highly schematic and a wide sprayer will typically include many more dispensing devices than those shown.
Furthermore, it should be understood that the dispense devices 16 may be for liquid or granular dispensing. Also foldaway drip pipes or soil injection apparatus may instead be supported by the boom 10.

Turning to Figure 2, each boom section 11-15 includes a lattice-like structure with horizontal members, vertical members and angled members, to be described in more detail below. The structure's pattern is substantially the same for all boom sections. However, the size of the repeating pattern is smaller for outer boom sections to reduce weight and the associated forces on the supporting joints.

Figures 3, 4 and 5 show the central, intermediate and outer boom section constructions respectively. The following description of the construction will refer directly to that of the boom section shown in Figure 3. However, the general pattern, construction and components employed are substantially the same as for the boom sections shown in Figure 4 and 5 also.

With reference to Figure 3, two upper transverse tubes 31, 32 and two lower transverse tubes 33, 34 extend from one end of the boom section 13 to the other. The transverse tubes 31-34 are formed of circular section material but may alternatively be formed of rectangular or trapezoid section for example. Furthermore, the transverse tubes 31-34 may be formed from steel or aluminium or other ridged material suitable for use. Conveniently, the tubes 31-34 may be identical in length and construction and so batches can be pre-cut ahead of assembly, thereby reducing lead time and factory costs.

The spatial relationship between the transverse tubes 31-34 is maintained by five upright members 20, all of the same size and construction and shown in detail in Figure 6. Each upright member 20 is formed by casting wherein a batch of many members can be formed in a single process. The design of the upright member 20 includes two upright pieces 21, 22 bridged by three transverse brace pieces 23, 24, 25. Although shown as a cast member, the upright member 20 may instead be formed by welding multiple components of section material.

At their lower end, upright pieces 21, 22 provide a pair of lower legs 26, 27 which each provide an integrated sleeve 28, 29 and terminate with a respective clamping element 61, 62.
The two lower transverse tubes 33, 34 pass through a respective one of the lower sleeves 28, 29 and are spaced apart thereby. The tubes 33, 34 are gripped within the respective sleeves 28, 29 by tightening the clamp elements 61, 62 using nuts and bolts (not shown). Alternatively, the tubes 33, 34 may be secured within their respective sleeves by gluing.

The upright pieces 21, 22 converge towards the top. At their upper ends, upright pieces 21, 22 include a pair of upper legs 63, 64 which each terminate with integrated sleeves 65, 66 which are bridged by brace element 25. In a similar manner to the lower transverse tubes, the two upper transverse tubes 31, 32 pass through a respective one of the upper sleeves 65, 66 and are gripped thereby.

By maintaining a parallel relationship between the transverse tubes 31-34 identical upright members 20 can be employed along the length of the boom section 13.

The upright members 20 are spaced at equal distances along the length of boom section 13 defining sub-sections having a repeating construction pattern. Each sub-section between adjacent upright members 20 includes first and second brace members 70, 80 extending across opposite diagonals and secured at each end to an upright member 20.

First brace member 70 (Figure 7) includes at its lower end a pair of legs 71, 72, each terminating with a respective jaw 71a, 72a. Each jaw 71a, 72a engages with a respective one of the lower legs 26, 27 of the upright members 20. Holes 71b, 72b provided in the jaw elements 71a, 72a align with holes provided in the lower legs 26 27 through which respective securing pins (not shown) are inserted.

The width of first brace member 70 narrows from it's lower end to it's upper end and terminates in a single leg which is secured between the two upper legs 63, 64 of the opposite upright member 20.

The second brace member 80 (Figure 8) includes at it's lower end a pair of legs 81, 82 which, in a similar manner to the first brace member 70, terminate with respective jaw elements 81a, 82a which engage the lower legs 26, 27 of upright member 20. The jaw elements 81a, 82a of second brace member 80 align on the inside of respective jaw elements 71a, 72a of first brace member 70. A single pin (not shown)
is inserted through holes 71b, 72b, 81b, 82b of first and second brace members 70, 80 and upright member 20 and secured with a clip for example.

Along its length, second brace member 80 narrows and terminates with a pair of jaw elements 83, 84 at its upper end which engage with upper legs 63, 64 of upright member 20. Holes provided in the jaw elements 83, 84, the single leg 73 and upper legs 63, 64 align with one another to allow a single pin to secure these elements together.

Second brace member 80 includes a central aperture 85 through which first brace member 70 passes. For increased rigidity and strength the two brace members are secured to another by a pin at their point of intersection.

It will be apparent to the skilled addressee that the repeating pattern of each sub-section of the boom section 13 allows for a small number of common components to be employed. In fact, the entire boom section 13 (disregarding consumables such as nuts and bolts) can be constructed from merely four different components thus minimising stocked components and 'dead' money.

Moreover, the use of nuts and bolts instead of welding provides an easier fabrication process thus saving time and costs.

The general construction of intermediate boom sections 12, 14, and outer boom sections 11, 15, as shown in Figures 4 and 5, is substantially the same as that described above reference to Figure 3. The modular nature of the boom section construction allows different boom lengths to be constructed from the same basic components using an integer number of repeating sub sections. To explain, the centre boom section 13 includes four repeating sub sections whereas the intermediate boom section 14 includes a five repeating sub-sections and the outer boom section 15 is formed of three repeating sub-sections. The manufacturer need only stock different lengths of transverse tubing to cater for the different lengths of boom section required whereas the other components are the same, albeit of a different size per boom section.

Different boom sections may employ transverse tubes having different wall thicknesses to provide the desired weight and strength. This applies especially to the lower transverse tubes which are in compression. For example, a boom section
towards the outside of the boom may employ a thinner (and thus lighter) tubular section for the transverse tubes than those for a boom section nearer to the centre of the boom.

Turning to the outer section 15 shown in Figure 5, a terminating construction (designated generally at 51) can be provided for boom sections employed at the end of multi-section booms. In this case the lower transverse tubes 53, 54 longer than the upper transverse tubes 55, 56 and extend further from the centre. A triangulating member 57 is formed with a similar construction to that of upright members 20 having four sleeves which engage the ends of transverse tubes 53 to 56, but having angled pieces. Suitable clamping means are also provided to secure the terminating member to the tubes.

Figures 9 and 10 illustrate an alternative embodiment. An upright member 90 includes a pair of lower open channels 91, 92 and a pair of upper channels 95, 96 each for receiving a respective transverse tube. Figure 10 shows one upper transverse tube 131 and one lower transverse tube 133 in place. In this case, the transverse tubes include vertical flanges which slot into and align with the associated channel. Holes are provided in the flanges which align with corresponding holes in the legs and receive bolts for securing the tubes in place.

In summary, there is provided a boom section for a multi-section boom of an agricultural sprayer. The boom section comprises two upper transverse tubes, two lower transverse tubes, and a plurality of upright members of the same construction and size serving to maintain a spatial relationship between the transverse tubes. The transverse tubes extend along the length of the boom section parallel to one another and are each formed from a continuous length of tubular material, preferably steel or aluminium. The upright members each comprise four transverse sleeves which each receive a respective one of the transverse tubes. The sleeves may be accompanied with clamping means to secure the transverse tube held therein.
CLAIMS

1. A boom section for a multi-section boom of an agricultural sprayer, the boom section comprising at least three transverse tubes, and a plurality of upright members of the same construction and size serving to maintain a spatial relationship between the transverse tubes, the transverse tubes extending along the length of the boom section parallel to one another and each being formed from a continuous length of tubular material, the upright members each comprising a respective transverse channel for each of the transverse tubes, each channel receiving a respective one of the transverse tubes.

2. A boom section according to Claim 1, comprising two horizontally aligned upper transverse tubes and a single lower transverse tube.

3. A boom section according to Claim 1, comprising two horizontally aligned lower transverse tubes and a single upper transverse tube.

4. A boom section according to Claim 1, comprising two horizontally aligned lower transverse tubes and two horizontally aligned upper transverse tubes.

5. A boom section according to any preceding claim, wherein the upright members further comprise a plurality of clamping means which each prevents movement of a respective one of the transverse tubes through its respective channel.

6. A boom section according to Claim 5, wherein each clamping means acts upon a respective channel to tighten that channel around the tube received thereby.

7. A boom section according to any one of Claims 1 to 4, wherein each upright member is secured to the transverse tubes by a glued joint.

8. A boom section according to any preceding claim, further comprising first and second brace members extending diagonally between adjacent upright members.

9. A boom section according to Claim 8, wherein the first brace member intersects the second brace member at a mid-point between the adjacent upright members.
10. A boom section according to Claim 9, wherein at the location of said intersection, the first brace member is narrower than the second brace and passes through an aperture in the second brace member.

11. A boom section according to Claim 10, wherein the first and second brace members are secured to one another at said point of intersection.

12. A boom section according to Claim 11, wherein the first and second brace members are secured to one another at said point of intersection by a pin which passes through holes formed in the first and second brace members.

13. A boom section according to any one of Claims 8 to 12, wherein the first and second brace members are secured at each end to the adjacent upright members.

14. A boom section according to Claim 13, wherein each upright member comprises two lower legs and two upper legs, each leg being integral with a respective one of said sleeves.

15. A boom section according to Claim 14, wherein at least one of the first and second braces comprises at one end a pair of jaws, each jaw receiving therein, and being secured to, a respective one of said legs of the upright members.

16. A boom section according to Claim 15, wherein the first and second brace members each comprise at a lower end a pair of legs each being integral with a respective one of said jaws, the first brace member comprising at an upper end a single leg which is secured between the two upper legs of an upright member, the second brace member comprising at an upper end a pair of legs each including a jaw which receives therein, and is secured to, a respective one of said upper legs of the upright members.

17. A boom section according to Claim 16, wherein a single securing pin passes through holes formed in the jaws of the second brace member, the two upper legs of the upright member and the single leg of the first brace member.

18. A boom section according to any preceding claim, wherein the transverse tubes are formed from aluminium or steel and the upright members are formed from a composite material.
19. A multi-section boom for an agricultural sprayer comprising a plurality of boom sections according to any preceding claim.

20. A method of manufacturing a boom section for a multi-section boom of an agricultural sprayer, the method comprising:
   - cutting at least three transverse tubes from one or more lengths of tubular material;
   - forming a plurality of upright members of the same construction and size and each having at least three parallel channels;
   - assembling the transverse tubes in a spaced parallel relationship by inserting the tubes through respective channels in the upright members, wherein two of the tubes are horizontally aligned and two of the tubes are vertically spaced from one another.

21. A method according to Claim 20, wherein the plurality of upright members are stockpiled before assembly.

22. A method according to Claim 20 or 21, wherein the upright members further comprise a plurality of clamping means, the method further comprising the step of tightening the clamping means to prevent movement of the transverse tubes through their respective channels.

23. A method according to any one of Claims 20 to 22, further comprising:
   - forming first and second brace members;
   - locating the first and second brace members so that they each extend diagonally between adjacent upright members;
   - then securing the first and second brace members in position with pins.

24. A method according to Claim 23, wherein the first brace member intersects the second brace member at a mid-point between the adjacent upright members.

25. A method according to Claim 24, further comprising securing the first and second brace members to one another by inserting a pin through holes formed in the first and second brace members at the point of intersection.
   - assembling a plurality of boom sections in accordance with the method of any one of Claims 20 to 25;
   - joining two or more of said boom sections to one another.

27. A method according to Claim 26, wherein the boom sections are stockpiled before being joined together.
A. CLASSIFICATION OF SUBJECT MATTER
INV. A01M7/00
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)
A01M

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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