



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.02.2014 Bulletin 2014/09

(51) Int Cl.:
E02F 3/38 (2006.01)

(21) Application number: **11863797.4**

(86) International application number:
PCT/JP2011/059748

(22) Date of filing: **20.04.2011**

(87) International publication number:
WO 2012/144037 (26.10.2012 Gazette 2012/43)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(71) Applicant: **Hitachi Construction Machinery Co., Ltd.**
Bunkyo-ku
Tokyo 112-0004 (JP)

(72) Inventors:
• **TAKAHASHI, Takeshi**
Tsuchiura-shi
Ibaraki 300-0013 (JP)
• **HAMADA, Atsushi**
Tsuchiura-shi
Ibaraki 300-0013 (JP)

• **SHIMODAIRA, Takayuki**
Tsuchiura-shi
Ibaraki 300-0013 (JP)
• **YAMAMOTO, Hikaru**
Tsuchiura-shi
Ibaraki 300-0013 (JP)
• **SUGAYA, Makoto**
Tsuchiura-shi
Ibaraki 300-0013 (JP)

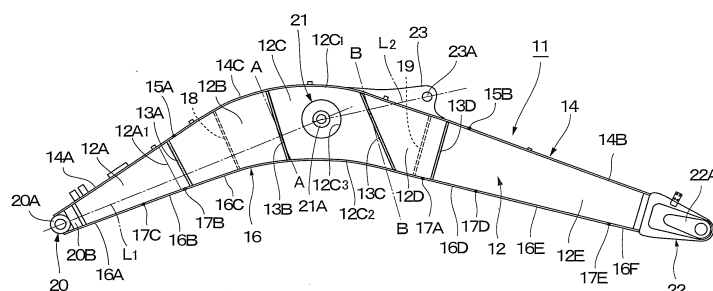
(74) Representative: **MERH-IP**
Matias Erny Reichl Hoffmann
Paul-Heyse-Strasse 29
80336 München (DE)

(54) **BOOM FOR CONSTRUCTION MACHINE**

(57) In left and right web plates (12) of a boom (11), first to fifth web materials (12A to 12E) are joined at edge portions in a front-rear direction along welding lines (13A to 13D). In an upper flange plate (14), a rear upper flange material (14A), a front upper flange material (14B), and a middle upper flange material (14C) are joined at edge portions in a front-rear direction along welding lines (15A, 15B). In a lower flange plate (16), first to sixth lower flange materials (16A to 16F) are joined at edge portions

in a front-rear direction along welding lines (17A to 17E). The welding lines (13A to 13D) of the left and right web plates (12) are disposed in positions that are different from those of the welding lines (15A, 15B) of the upper flange plate (14) and the welding lines (17A to 17E) of the lower flange plate (16) in a front-rear direction. This makes it possible to reduce the entire weight and thereby achieve reduction in weight while ensuring bending strength, torsional strength, and the like of the boom (11).

Fig. 2



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a boom for a construction machine, the boom suitably used, as a working arm, in a working mechanism of a hydraulic excavator, for example.

BACKGROUND ART

10 **[0002]** In general, a working mechanism provided in a construction machine such as a hydraulic excavator is formed of a boom that is coupled, at the base end side thereof, to a frame of a vehicle body side in such a way that the boom can move upward and downward, an arm that is rotatably coupled to the distal end side of the boom, a working tool such as an excavating bucket that is rotatably coupled to the distal end side of the arm, a boom cylinder, an arm cylinder, and a working tool cylinder that operate the boom, the arm, and the working tool, respectively.

15 **[0003]** Of the working mechanism described above, the boom is formed as a box shape structural body formed of left and right web plates, an upper flange plate joined to the upper end sides of the left and right web plates by welding, and a lower flange plate joined to the lower end sides of the left and right web plates by welding, the box shape structural body being a closed section structure which is quadrangular in cross section. The boom forms a working arm for a construction machine, and the working arm is a long welded structure with an overall length of several meters or more.

20 **[0004]** Consequently, a production process, including a welding operation, of the boom as a working arm for a construction machine requires much time and effort, and improving the workability at the time of assembly has become a great problem. As part of methods to solve this problem, for example, a method for assembling a long boom by dividing the boom into three parts in a length direction and manufacturing them as three box shape structural body in advance and then joining the box shape structural body to one another in a front-rear direction by welding has been known (Patent Document 1).

PRIOR ART DOCUMENT

PATENT DOCUMENT

30 **[0005]** Patent Document 1: Japanese Examined Utility Model Publication No. Sho 61-11329 Y2

SUMMARY OF THE INVENTION

35 **[0006]** Incidentally, the boom by the conventional art has to be formed to have a solid structure because the boom is under an impactive load due to the excavation reaction force generated at the time of excavation operation to excavate earth and sand, for example, and great bending moment, torsional moment, and the like are applied thereto. It is for this reason that the bending strength, the torsional strength, and the like of the left and right web plates and the upper and lower flange plates which form the boom are also heightened by increasing the plate thicknesses thereof.

40 **[0007]** However, the thicker the plate materials forming the left and right web plates and the upper and lower flange plates get, the heavier the entire boom gets and the higher the cost of material gets. In addition, this increases the inertial force when the boom is moved upward and downward by the boom cylinder, making it difficult to improve the positioning performance when the boom is stopped in a desired position. Furthermore, since there is a need to use a large hydraulic cylinder as the boom cylinder, reducing the weight of the boom has become a great problem.

45 **[0008]** The present invention has been made in view of the above-described problems of the conventional art, and an object of the present invention is to provide a boom for the construction machine, the boom that can achieve reduction in weight by reducing the overall weight while ensuring sufficient bending strength, torsional strength, and the like.

50 (1) To solve the problems described above, the present invention is applied to a boom for the construction machine including: left and right web plates; an upper flange plate that is joined to upper end sides of the left and right web plates by welding; and a lower flange plate that is joined to lower end sides of the left and right web plates by welding, the boom is formed of the left and right web plates and the upper and lower flange plates, and formed as the box shape structural body being a closed section structure which is quadrangular in cross section.

55 **[0009]** A feature of the configuration adopted by the invention of claim 1 is that the left web plate and the right web plate are each formed by joining a total of at least five plate materials having different shapes at edge portions in a front-rear direction along welding lines, the upper flange plate is formed by joining a total of at least three plate materials having different shapes at edge portions in a front-rear direction along welding lines, the lower flange plate is formed by

joining a total of at least six plate materials having different shapes at edge portions in a front-rear direction along welding lines, end portions of the welding lines between the plate materials forming the upper flange plate and end portions of the welding lines between the plate materials forming the left and right web plates are disposed in positions that are different from one another in a front-rear direction, and end portions of the welding lines between the plate materials forming the lower flange plate and the end portions of the welding lines between the plate materials forming the left and right web plates are disposed in positions that are different from one another in a front-rear direction.

[0010] With this arrangement, the left web plate and the right web plate can be formed by joining a total of at least five plate materials having different shapes at edges in a front-rear direction along welding lines. The upper flange plate can be formed by joining a total of at least three plate materials having different shapes at edges in a front-rear direction along welding lines, and the lower flange plate can be formed by joining a total of at least six plate materials having different shapes at edges in a front-rear direction along welding lines. When a box shape structural body which is a quadrangular in cross section is formed by using the left and right web plates, the upper flange plate, and the lower flange plate, the end portions of the welding lines between the plate materials forming the left and right web plates can be disposed in positions that are different, in a front-rear direction, from the positions of the end portions of the welding lines between the plate materials forming the upper flange plate and the end portions of the welding lines between the plate materials forming the lower flange plate. As a result, since it is possible to prevent overlapping of the welding line end portions at which welding defects easily occur, it is possible to reduce the possibility of the occurrence of welding defects and produce a boom with a high-strength welding structure. This makes it possible to reduce the plate thicknesses of the plate materials forming the boom and reduce the entire weight and thereby achieve reduction in weight. Moreover, it is possible to increase impact resistance of the boom to the excavation reaction force or the like and ensure sufficient bending strength and torsional strength.

(2) The present invention adopts a configuration in which, a boom foot-side mounting member that is located on a rear end side in a front-rear direction and is welded between the upper and lower flange plates, and a boom cylinder mounting member that is welded to the plate material located in the middle-most of the five plate materials in a front-rear direction, and a boom cylinder is rotatably coupled thereto, are provided between the left and right web plates, and of the five plate materials forming the left and right web plates, the plate thicknesses of the plate material on the rear end side to which the boom foot-side mounting member is welded, and the plate material located in the middle are made greater than the plate thicknesses of the other three plate materials.

[0011] With this arrangement, of the five plate materials forming the left and right web plates, for the plate material located in the middle-most in a front-rear direction and the plate material on a rear end side, the plate material in which the boom foot-side mounting member is provided, a thick plate material can be used, and, for the other three plate materials, a thin plate material can be used. As a result, the plate material on the rear end side can support the boom foot-side mounting member with a solid structure with the upper and lower flange plates, making it possible to increase the support strength. The plate material located in the middle can support, with a solid structure, the boom cylinder mounting member to which the boom cylinder is rotatably coupled, making it possible to increase the support strength.

(3) The present invention adopts a configuration in which, a boom foot-side mounting member that is located on a rear end side in a front-rear direction and is welded between the upper and lower flange plates, and a boom cylinder mounting member that is welded to the plate material located in the middle-most of the five plate materials in a front-rear direction and a boom cylinder is rotatably coupled thereto, are provided between the left and right web plates, an arm cylinder mounting member which is located in a position closer to a front side than the boom cylinder mounting member and in a top face of the plate material located in the middle of the three plate materials, and an arm cylinder is rotatably coupled thereto, is provided in the upper flange plate, and in the plate material located in the middle of each of the left and right web plates, the welding line on a rear side in a front-rear direction is disposed so as to be nearly orthogonal to a first reference line connecting the boom foot-side mounting member and the boom cylinder mounting member and the welding line on a front side in a front-rear direction is disposed so as to be nearly orthogonal to a second reference line connecting the boom cylinder mounting member and the arm cylinder mounting member.

[0012] With this arrangement, in the plate material located in the middle-most in a front-rear direction of a total of five plate materials forming the left and right web plates, the welding line between the plate material located in the middle and the adjacent plate material joined to the rear end portion thereof can be disposed in a position that is nearly orthogonal to the first reference line. This makes it possible to increase the welding strength between the plate material located in the middle and the adjacent plate material located on a rear side to the stress that is produced between the boom cylinder mounting member to which the boom cylinder is coupled and the boom foot-side mounting member.

[0013] On the other hand, in the plate material located in the middle, the welding line between the plate material located in the middle and another adjacent plate material joined to the rear end portion thereof can be disposed in a position

that is nearly orthogonal to the second reference line. This makes it possible to increase the welding strength between the plate material located in the middle and the other adjacent plate material to the stress that is produced between the boom cylinder mounting member to which the boom cylinder is coupled and the arm cylinder mounting member to which the arm cylinder is coupled.

(4) The present invention adopts a configuration in which the left and right web plates are each formed of a total of five plate materials, such as, a first web material located on a rear end side in a front-rear direction, a second web material whose rear end portion is joined to a front end portion of the first web material, a third web material whose rear end portion is joined to a front end portion of the second web material, a fourth web material whose rear end portion is joined to a front end portion of the third web material, and a fifth web material whose rear end portion is joined to a front end portion of the fourth web material, and between the second web materials forming the left and right web plates, a first partition plate is provided so as to be located between the upper and lower flange plates, and, between the fourth web materials, a second partition plate is provided so as to be located between the upper and lower flange plates.

[0014] With this arrangement, of the left and right web plates formed of the first to fifth web materials, between the second web materials, the first partition plate can be provided by being joined by welding so as to be located between the upper and lower flange plates, and, with the first partition plate, it is possible to increase the joint strength between the left and right web plates and the upper and lower flange plates by welding. On the other hand, of the left and right web plates, between the fourth web materials, the second partition plate can be provided by being joined by welding so as to be located between the upper and lower flange plates, and, with the second partition plate, it is possible to increase the joint strength between the left and right web plates and the upper and lower flange plates by welding.

(5) The present invention adopts a configuration in which, an arm-side mounting member that is located on a front end side in a front-rear direction and is welded between the upper and lower flange plates is provided in the left and right web plates. This makes it possible to provide the arm-side mounting member between an area located on a front end side of the entire length of the left and right web plates and the upper and lower flange plates by joining the arm-side mounting member therebetween by welding and rotatably couple an arm to the distal end side of the boom with the arm-side mounting member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a front view showing a hydraulic excavator in which a boom according to a first embodiment of the present invention is provided.

Fig. 2 is a front view showing the boom in Fig. 1 as a single unit.

Fig. 3 is a partially enlarged view of Fig. 2, showing a middle portion of the boom in a length direction thereof.

Fig. 4 is an exploded perspective view showing plate materials forming the boom.

Fig. 5 is an exploded perspective view of the boom, showing a state in which the plate materials forming a web plate and an upper flange plate in Fig. 2 are joined, respectively.

Fig. 6 is a perspective view showing a state in which the left and right web plates and the upper flange plate are integrally assembled by welding.

Fig. 7 is a perspective view showing a state in which internal welding is performed on the inner surfaces of the left and right web plates and the upper flange plate, which was integrally assembled.

Fig. 8 is a perspective view showing a state in which a lower flange plate is joined to the left and right web plates, which were integrally assembled.

Fig. 9 is a perspective view showing a state in which external welding is performed, by robots, on the left and right web plates and the upper and lower flange plates, which were, integrally assembled.

Fig. 10 is an exploded perspective view showing plate materials forming a boom according to a second embodiment.

MODE FOR CARRYING OUT THE INVENTION

[0016] Hereinafter, a boom for the construction machine according to embodiments of the present invention will be described in detail in accordance with the accompanying drawings, by taking a case in which the boom for the construction machine is applied to a boom of a hydraulic excavator.

[0017] Here, Figs. 1 to 9 show a boom of a hydraulic excavator according to a first embodiment of the present invention.

[0018] In the drawings, designated at 1 is a hydraulic excavator as a construction machine, and, as shown in Fig. 1,

the hydraulic excavator 1 is largely constituted by an automotive crawler-type lower traveling structure 2, an upper revolving structure 3 rotatably mounted on the lower traveling structure 2, and a working mechanism 8 which will be described later. The upper revolving structure 3 of the hydraulic excavator 1 forms a vehicle body of the construction machine with the lower traveling structure 2. The upper revolving structure 3 is formed of a revolving frame 4, a cab 5, a counterweight 6, a housing cover 7, and the like, which will be described later.

[0019] Indicated at 4 is the revolving frame forming a frame of the upper revolving structure 3, and the working mechanism 8 which will be described later is liftably attached on the front side of the revolving frame 4, and the counterweight 6 which will be described later is attached on its rear side. The cab 5 is disposed in the left front portion of the revolving frame 4, and the cab 5 defines an operator's room inside. In the cab 5, an operator's seat in which an operator sits, an operating lever, a lever or pedal for travelling (none of which is illustrated), and the like are disposed therein.

[0020] Indicated at 6 is the counterweight provided on a rear end side of the revolving frame 4, and the counterweight 6 is detachably mounted on the rear end side of the revolving frame 4 to keep a weight balance of the entire upper revolving structure 3 with respect to the working mechanism 8 on the front side. In front side of the counterweight 6, the housing cover 7, which will be described later, that accommodates an engine (not shown) and the like is provided.

[0021] Indicated at 7 is the housing cover, which is located between the cab 5 and the counterweight 6 and is vertically provided on the revolving frame 4. The housing cover 7 is formed in a housing structure by using a plurality of metal panels and the like formed of a thin steel sheet, for example, and defines a machine room (not shown) accommodating the engine and the like, therein.

[0022] Designated at 8 is the working mechanism liftably provided in the front portion of the upper revolving structure 3, and the working mechanism 8 is largely constituted by a boom 11 which will be described later, an arm 9 that is liftably attached to the distal end side of the boom 11, and a bucket 10, as a working tool, that is rotatably provided at the distal end side of the arm 9 to perform excavation operation on earth and sand, for example. The boom 11 of the working mechanism 8 is moved upward and downward with respect to the revolving frame 4 by a boom cylinder 11A, and the arm 9 is moved upward and downward by an arm cylinder 9A at the distal end side of the boom 11. The bucket 10 as the working tool is rotated up and down by a bucket cylinder 10A at the distal end side of the arm 9.

[0023] Designated at 11 is the boom forming a working arm of the working mechanism 8, and the boom 11 is formed as a long box shape structural body as shown in Fig. 1 and is moved upward and downward with respect to the revolving frame 4 by the boom cylinder 11A. As shown in Figs. 2, 6, and 9, the boom 11 is formed of a pair of left and right web plates 12 and 12 extending in a length direction (a front-rear direction) of the boom 11 and facing each other in a left-right direction and upper and lower flange plates 14 and 16 joined to both upper and lower end sides of each of the web plates 12 by welding, and the boom 11 is formed as the box shape structural body being a closed section structure which is quadrangular in cross section.

[0024] The left and right web plates 12 and the upper and lower flange plates 14 and 16 are formed by using a plate material made of high-tensile steel in the 550 to 600 Mpa (megapascals) class, for example, making it possible to minimize the plate thickness of each plate material. Likewise, partition plates 18 and 19, boss members 20 and 21, and bracket members 22 and 23, which will be described later, are also formed by using steel made of similar high-tensile steel.

[0025] Next, the configuration of the left and right web plates 12 will be specifically described.

[0026] Indicated at 12 is a pair of left and right web plates forming the side faces of the boom 11. Incidentally, since the left web plate 12 and the right web plate 12 are formed so as to have the same shape, one web plate 12 will be explained. Moreover, a rear end side in a front-rear direction which is a length direction of the boom 11 corresponds to a rear side of the boom 11 when viewed from the backward of the vehicle of the hydraulic excavator 1, and a front end side in a front-rear direction corresponds to a front side (a distal end side) of the boom 11 when viewed from the backward of the vehicle of the hydraulic excavator 1.

[0027] As shown in Fig. 4, the web plate 12 is formed of a total of five plate materials such as a first web material 12A located on the rear end side (the foot side of the boom 11) of the entire length of the web plate 12 and a second web material 12B, a third web material 12C, a fourth web material 12D, and a fifth web material 12E which are located in order in front of the first web material 12A and have different shapes.

[0028] Of these web materials, the first web material 12A located at the rearmost end in a front-rear direction is formed in the shape of a quadrangle whose vertical width is gradually increased with distance from the rear side as it gets near the front side by performing press forming on a flat plate material made of the high-tensile steel. Furthermore, the first web material 12A is bent in the position of a bending line 12A1 closer to the front side in such a way that the first web material 12A is curved to the outside in a left-right direction. The next second web material 12B is also formed in the shape of a quadrangle whose vertical width is gradually increased with distance from the rear side as it gets near the front side by performing press forming on a flat plate material made of the high-tensile steel.

[0029] Of the web plates 12, the third web material 12C located in the middle-most in a front-rear direction is formed in the shape of a parallelogram as shown in Fig. 2 by performing press forming on a flat plate material made of the high-tensile steel. Furthermore, both upper and lower end sides of the third web material 12C are arc-shaped edge portions 12C1 and 12C2, each having a previously determined curvature. Of the edge portions 12C1 and 12C2, the upper edge

portion 12C1 is formed so as to have a radius of curvature of about 1800 mm, for example, and the lower edge portion 12C2 is also formed so as to have a substantially similar radius of curvature. In the third web material 12C, a circular punching hole 12C3 is formed between the edge portions 12C1 and 12C2, and, to the punching hole 12C3, an annular flange portion 21B of the boss member 21, which will be described later, is joined by welding.

[0030] The fourth web material 12D is formed in the shape of a trapezoid with an upper base longer than a lower base by performing press forming on a flat plate material made of the high-tensile steel. Therefore, the boom 11 has a shape whose middle portion in a length direction is curved in an arched shape by the presence of the third web materials 12C and the fourth web materials 12D of the left and right web plates 12.

[0031] Of the web plates 12, the fifth web material 12E located at the forefront (the front end side) in a front-rear direction is formed in the shape of a quadrangle whose vertical width is gradually decreased with distance from the rear side as it gets near the front side by performing press forming on a flat plate material made of the high-tensile steel. Of the first to fifth web materials 12A to 12E, the fifth web material 12E is formed so as to have the greatest length in a front-rear direction and the smallest plate thickness.

[0032] As shown in Fig. 5, the second web material 12B is joined, at a rear end portion thereof, to a front end portion of the first web material 12A along a welding line 13A. In the position of the welding line 13A, butt welding with a V-shaped groove is performed, and the welding line 13A has one end portion 13A1 and the other end portion 13A2. The third web material 12C is joined, at a rear end portion thereof, to a front end portion of the second web material 12B along a welding line 13B. Also in the position of the welding line 13B, butt welding with a V-shaped groove is performed, and the welding line 13B has one end portion 13B1 and the other end portion 13B2.

[0033] The fourth web material 12D is joined, at a rear end portion thereof, to a front end portion of the third web material 12C along a welding line 13C. Also in the position of the welding line 13C, butt welding with a V-shaped groove is performed, and the welding line 13C has one end portion 13C1 and the other end portion 13C2. Furthermore, the fifth web material 12E is joined, at a rear end portion thereof, to a front end portion of the fourth web material 12D along a welding line 13D. Also in the position of the welding line 13D, butt welding with a V-shaped groove is performed, and the welding line 13D has one end portion 13D1 and the other end portion 13D2.

[0034] Of the first to fifth web materials 12A to 12E forming the web plate 12, the first web material 12A and the third web material 12C share the greatest load, and, as an example, the plate thickness $t1a$ of the first web material 12A and the plate thickness $t1c$ of the third web material 12C are formed so as to be about 14 mm, for example. On the other hand, the plate thickness $t1b$ of the second web material 12B and the plate thickness $t1d$ of the fourth web material 12D are formed so as to be about 10 mm, for example. The plate thickness $t1e$ of the fifth web material 12E is about 9 mm, for example, and is formed so as to be the smallest thickness. Therefore, the plate thicknesses $t1a$ to $t1e$ of the first to fifth web materials 12A to 12E have the following relationship.

[Formula 1]

$$t1a = t1c > t1b = t1d > t1e$$

[0035] Here, as shown in Figs. 2 and 3, the welding line 13B between the second web material 12B and the third web material 12C is disposed in a position forming an angle $\theta 1$ (for example, $\theta 1 \approx 4.5$ to 4.9 degrees) with a first orthogonal line A-A, which will be described later, in a range close thereto. On the other hand, as shown in Figs. 2 and 3, the welding line 13C between the third web material 12C and the fourth web material 12D is disposed in a position forming an angle $\theta 2$ (for example, $\theta 2 \approx 10.5$ to 11.5 degrees) with a second orthogonal line B-B, which will be described later, in a range close thereto.

[0036] A point of intersection of the upper edge portion 12C1 of the third web material 12C and the end portion 13C1 of the welding line 13C is disposed in a position closer to the front than a rear end portion of the bracket member 23, which will be described later, by a dimension a (for example, $a \approx 113$ to 116 mm). A point of intersection of the lower edge portion 12C2 of the third web material 12C and the end portion 13C2 of the welding line 13C is disposed in a position closer to the rear than a lower end portion of the partition plate 19, which will be described later, by a dimension b (for example, $b = 100$ mm).

[0037] Next, the configuration of the upper flange plate 14 will be specifically described.

[0038] Indicated at 14 is the upper flange plate that is joined to the upper end sides of the left and right web plates 12 by fillet welding. That is, as shown in Fig. 4, the upper flange plate 14 is formed of a total of three plate materials such as a rear upper flange material 14A which is located on the rear side in a front-rear direction of the entire length of the upper flange plate 14, a front upper flange material 14B located on the front side in a front-rear direction, and a middle upper flange material 14C disposed between the rear upper flange material 14A and the front upper flange material 14B. The middle upper flange material 14C is disposed in a position in which the middle upper flange material 14C covers the boss member 21, which will be described later, from above.

[0039] The rear upper flange material 14A, the front upper flange material 14B, and the middle upper flange material 14C are each formed in the shape of a quadrangle by performing press forming on a flat plate material made of the high-tensile steel, have different shapes, and extend in a front-rear direction. The rear upper flange material 14A has the shortest length dimension, the middle upper flange material 14C has the longest thereof, and the front upper flange material 14B is formed so as to be intermediate in length dimension between the rear upper flange material 14A and the middle upper flange material 14C.

[0040] In the upper flange plate 14, since the bracket member 23 which will be described later is joined to the outer side face of the middle upper flange material 14C, the plate thickness $t2c$ of the middle upper flange material 14C is the greatest thickness and is formed so as to be a plate thickness of about 14 mm, for example. The plate thickness $t2a$ of the rear upper flange material 14A is formed so as to be an intermediate plate thickness of about 10 mm, for example, and the plate thickness $t2b$ of the front upper flange material 14B is about 8 mm, for example, and is formed so as to be the smallest thickness. Therefore, the plate thickness $t2a$ of the rear upper flange material 14A, the plate thickness $t2b$ of the front upper flange material 14B, and the plate thickness $t2c$ of the middle upper flange material 14C have the following relationship.

[Formula 2]

$$t2c > t2a > t2b$$

[0041] As shown in Figs. 4 and 5, the middle upper flange material 14C is joined, at a rear end portion thereof, to a front end portion of the rear upper flange material 14A along a welding line 15A. Butt welding with a V-shaped groove is performed in the position of the welding line 15A, and the welding line 15A has one end portion 15A1 and the other end portion 15A2. The front upper flange material 14B is joined, at a rear end portion thereof, to a front end portion of the middle upper flange material 14C along a welding line 15B. Butt welding with a V-shaped groove is performed also in the position of the welding line 15B, and the welding line 15B has one end portion 15B1 and the other end portion 15B2.

[0042] In a state in which the middle upper flange material 14C is joined between the rear upper flange material 14A and the front upper flange material 14B along the welding lines 15A and 15B, rolling process after joining the plates is performed on the upper flange plate 14. As a result, the upper flange plate 14 is curved as shown in Fig. 5. That is, the rear upper flange material 14A and the middle upper flange material 14C of the upper flange plate 14 are curved into a shape that follows the arc-shaped contour of the upper end side of the web plate 12.

[0043] As shown in Figs. 6 and 7, the upper flange plate 14 formed of the rear upper flange material 14A, the front upper flange material 14B, and the middle upper flange material 14C is joined to the upper end sides of the left and right web plates 12 by welding. At this time, the welding lines 13A, 13B, 13C, and 13D of the web plates 12 are disposed in such a way that the welded positions of the end portions 13A1, 13B1, 13C1, and 13D1 thereof do not overlap the welded positions of the end portions 15A1 and 15B1 (the end portions 15A2 and 15B2) of the welding lines 15A and 15B of the upper flange plate 14. That is, the end portions 13A1, 13B1, 13C1, and 13D1 of the welding lines 13A to 13D and the end portions 15A1 and 15B1 (the end portions 15A2 and 15B2) of the welding lines 15A and 15B are disposed in positions that are different from each other in a front-rear direction of the boom 11.

[0044] Next, the configuration of the lower flange plate 16 will be specifically described.

[0045] Indicated at 16 is the lower flange plate joined to the lower end sides of the left and right web plates 12 by welding. That is, as shown in Fig. 4, the lower flange plate 16 is formed of a total of six plate materials which are disposed so as to be arranged in order from the rear side to the front side in a front-rear direction of the entire length of the lower flange plate 16, such as a first lower flange material 16A, a second lower flange material 16B, a third lower flange material 16C, a fourth lower flange material 16D, a fifth lower flange material 16E, and a sixth lower flange material 16F. Of these lower flange materials, the third lower flange material 16C is disposed in a position below the boss member 21 which will be described later.

[0046] The lower flange materials 16A to 16F are each formed in the shape of a quadrangle by performing press forming on a flat plate material made of the high-tensile steel, have different shapes, and extend in a front-rear direction. The third lower flange material 16C located in the middle in a front-rear direction is formed so as to be the longest, and the second lower flange material 16B and the sixth lower flange material 16F are formed so as to be the shortest. The fourth lower flange material 16D is formed so as to be longer than the second and sixth lower flange materials 16B and 16F. The first lower flange material 16A and the fifth lower flange material 16E are formed so as to be shorter than the third lower flange material 16C and longer than the fourth lower flange material 16D.

[0047] In the lower flange plate 16, the plate thickness $t3c$ of the third lower flange material 16C located in the middle in a front-rear direction is the greatest thickness and is formed so as to be about 12 mm, for example. The plate thicknesses $t3a$ and $t3b$ of the first and second lower flange materials 16A and 16B are formed so as to be about 9 mm, for example.

The plate thicknesses t_{3d} , t_{3e} , and t_{3f} of the fourth, fifth, and sixth lower flange materials 16D, 16E, and 16F are about 8 mm, for example, and are formed so as to be the smallest thickness. Therefore, the plate thicknesses t_{3a} to t_{3f} of the first to sixth lower flange materials 16A to 16F have the following relationship.

[Formula 3]

$$t_{3c} > t_{3a} = t_{3b} > t_{3d} = t_{3e} = t_{3f}$$

[0048] As shown in Fig. 4, rolling process before joining the plates is performed on the third lower flange material 16C, and the third lower flange material 16C is curved into a shape that follows the arc-shaped contour of the lower end side of the web plate 12. Then, a front end portion of the third lower flange material 16C is joined to a rear end portion of the fourth lower flange material 16D along a welding line 17A, and butt welding with a V-shaped groove is performed in the position of the welding line 17A. As shown in Fig. 5, the welding line 17A has one end portion 17A1 and the other end portion 17A2. As shown in Fig. 8, the third lower flange material 16C and the fourth lower flange material 16D which were joined to each other are joined, by welding, to the left and right web plates 12 which were integrally assembled and welded to the upper flange plate 14, in such a way as to close partially a lower end side of a middle part thereof in a length direction.

[0049] Next, in the lower flange plate 16, the short length second lower flange material 16B and the short length sixth lower flange material 16F are joined to the left and right web plates 12 by welding in such a way as to close partially the lower end side thereof. At this time, a rear end portion of the second lower flange material 16B is joined to a front end portion of the third lower flange material 16C along a welding line 17B (see Fig. 9), and, in the position of the welding line 17B, both side welding of the inside and the outside is performed in a state in which they are butted. As shown in Fig. 9, the welding line 17B has one end portion 17B1 and the other end portion 17B2.

[0050] The first lower flange material 16A and the fifth lower flange material 16E form a lid member that finally closes the openings between each web plates 12 of a boom assembly body 31 which will be described later. That is, when assembling welding is performed on the boom 11 forming a quadrangular closed section structure, the first lower flange material 16A and the fifth lower flange material 16E are joined to the left and right web plates 12 by welding in such a way as to close the lower end side thereof finally. At this time, a rear end portion of the first lower flange material 16A is joined to a front end portion of the second lower flange material 16B along a welding line 17C (see Fig. 9), and butt welding with a V-shaped groove using a backing material (not shown) is performed in the position of the welding line 17C. As shown in Fig. 9, the welding line 17C has one end portion 17C1 and the other end portion 17C2.

[0051] Moreover, a rear end portion of the fifth lower flange material 16E is joined to a front end portion of the fourth lower flange material 16D along a welding line 17D, and a front end portion of the fifth lower flange material 16E is joined to a rear end portion of the sixth lower flange material 16F along a welding line 17E. Also, in this case, in the positions of the welding lines 17D and 17E, butt welding with a V-shaped groove using a backing material (not shown) is performed. As shown in Fig. 9, the welding line 17D has one end portion 17D1 and the other end portion 17D2, and the welding line 17E has one end portion 17E1 and the other end portion 17E2.

[0052] The welding line 17A of the lower flange plate 16 is disposed in such a way that the welded positions of the end portions 17A1 and 17A2 thereof do not overlap the welded positions of the end portions 13C2 and 13D2 of the welding lines 13C and 13D of the left and right web plates 12. That is, the end portions 13C2 and 13D2 of the welding lines 13C and 13D and the end portions 17A1 and 17A2 of the welding line 17A are disposed in positions that are different from one another in a front-rear direction of the boom 11. The end portions 17B1 and 17B2 of the welding line 17B are disposed in such a way that the welded positions thereof do not overlap the welded positions of the end portions 13A2 of the welding lines 13A of the web plates 12. That is, the end portions 13A2 of the welding lines 13A and the end portions 17B1 and 17B2 of the welding line 17B are disposed in positions that are different from one another in a front-rear direction of the boom 11.

[0053] The end portions 17C1 and 17C2 of the welding line 17C are also disposed in such a way that the welded positions thereof do not overlap the welded positions of the end portions 13A2 of the welding lines 13A of the web plates 12, for example. That is, the end portions 13A2 of the welding lines 13A and the end portions 17C1 and 17C2 of the welding line 17C are disposed in positions that are different from one another in a front-rear direction of the boom 11. The end portions 17D1 and 17D2 of the welding line 17D are also disposed in such a way that the welded positions thereof do not overlap the welded positions of the end portions 13D2 of the welding lines 13D, for example. That is, the end portions 13D2 of the welding lines 13D and the end portions 17D1 and 17D2 of the welding line 17D are disposed in positions that are different from one another in a front-rear direction of the boom 11. Likewise, the end portions 17E1 and 17E2 of the welding line 17E are also disposed in such a way that the welded positions thereof do not overlap the welded positions of the end portions 13D2 of the welding lines 13D, for example. That is, the end portions 13D2 of the welding lines 13D and the end portions 17E1 and 17E2 of the welding line 17E are disposed in positions that are different

from one another in a front-rear direction of the boom 11.

[0054] Indicated at 18 is the first partition plate as a partition wall provided within the boom 11, and the first partition plate 18 is provided by being joined between the second web materials 12B forming the left and right web plates 12 and between the upper and lower flange plates 14 and 16 by means of fillet welding or the like. The upper end of the first partition plate 18 is joined to the middle upper flange material 14C of the upper flange plate 14 by means of fillet welding or the like. The lower end of the first partition plate 18 is joined to the third lower flange material 16C of the lower flange plate 16 by means of fillet welding or the like. The left and right ends of the first partition plate 18 are joined to the second web materials 12B of the left and right web plates 12 by means of fillet welding or the like.

[0055] Indicated at 19 is the second partition plate as a partition wall provided within the boom 11, and the second partition plate 19 is provided by being joined between the fourth web materials 12D forming the left and right web plates 12 and between the upper and lower flange plates 14 and 16 by means of fillet welding or the like. The upper end of the second partition plate 19 is joined to the middle upper flange material 14C of the upper flange plate 14 by means of fillet welding or the like. The lower end of the second partition plate 19 is joined to the third lower flange material 16C of the lower flange plate 16 by means of fillet welding or the like. The left and right ends of the third partition plate 19 are joined to the fourth web materials 12D of the left and right web plates 12 by means of fillet welding or the like.

[0056] Next, the configurations of a boom foot-side mounting member, a boom cylinder mounting member, an arm-side mounting member, and an arm cylinder mounting member which are attached to the boom 11 will be specifically described.

[0057] Indicated at 20 is the boss member forming the boom foot-side mounting member. As shown in Figs. 4 and 5, the boss member 20 is formed of a tubular boss portion 20A extending in a left-right direction and left and right connecting portions 20B which are integrally formed at the both end sides of the boss portion 20A. The connecting portions 20B of the boss member 20 are joined to the rear end sides of the first web materials 12A of the left and right web plates 12 with welding means with a rear V-shaped groove, for example. To the boss portion 20A of the boss member 20, the rear ends of the upper and lower flange plates 14 and 16 (that is, the rear end of the rear upper flange material 14A and the rear end of the first lower flange material 16A) are joined with welding means so as to sandwich the boss portion 20A in a vertical direction.

[0058] As a result, the boss member 20 is provided so that it is located at the rear end (the base end) side of the boom 11 and welded between the rear ends of the left and right first web materials 12A, the rear end of the rear upper flange material 14A, and the rear end of the first lower flange material 16A. The boss member 20 forms a boom foot portion for liftably pin-coupling the base end side of the boom 11 to the revolving frame 4 (see Fig. 1) of the upper revolving structure 3.

[0059] Indicated at 21 is the other boss member forming the boom cylinder mounting member provided in a middle part of the boom 11 in a length direction thereof. As shown in Figs. 4 and 5, the boss member 21 is formed of a tubular boss portion 21A extending in a left-right direction and left and right annular flange portions 21B which are integrally formed at the both end sides of the boss portion 21A. The annular flange portions 21B of the boss member 21 are fit into the third web materials 12C of the left and right web plates 12 through the punching holes 12C3 and are joined to the areas around the punching holes 12C3 by using welding means with a rear V-shaped groove, for example. As shown in Fig. 1, to the boss portion 21A of the boss member 21, a rod side of the boom cylinder 11A is rotatably pin-coupled.

[0060] Here, as shown in Figs. 2 and 3, when there is a first reference line L1 connecting the centers of the boss portion 20A of the boss member 20 and the boss portion 21A of the boss member 21, assume that there is a first orthogonal line A-A orthogonal to the reference line L1. Of the left and right web plates 12, each third web material 12C located in the middle-most in a front-rear direction is disposed in a range close to the first orthogonal line A-A in such a way that the welding line 13B between the third web material 12C and the adjacent second web material 12B is nearly orthogonal to the first reference line L1. An angle θ_1 which the first orthogonal line A-A and the welding line 13B form is set at an angle of 5 degrees or less (for example, $\theta_1 \approx 4.5$ to 4.9 degrees).

[0061] Moreover, assume that there is a perpendicular line K perpendicular to the arc-shaped edge portion 12C1 located on the upper end side of the third web material 12C, the welding line 13B is inclined on one side with respect to the perpendicular line K at an angle α (for example, $\alpha \approx 4.7$ to 4.8 degrees) and is inclined on the other side with respect to the first orthogonal line A-A by an angular difference θ_1 . That is, with regard to an angle β between the first orthogonal line A-A and the perpendicular line K, $\beta = \alpha + \theta_1$ holds, and it is preferable that the angle θ_1 and the angle α be set at angles, which are nearly equal to each other.

[0062] Indicated at 22 is the bracket member forming the arm-side mounting member provided on the front end (the tip) side of the boom 11. The bracket member 22 is formed of a pair of left and right bifurcated bracket portions 22A and a joint portion 22B integrally coupling the bracket portions 22A. The rear ends of the left and right bracket portions 22A are joined to the front end sides of the left and right fifth web materials 12E by using welding means with a rear V-shaped groove, for example. To the joint portion 22B of the bracket member 22, the front ends of the upper and lower flange plates 14 and 16 (that is, the front end of the front upper flange material 14B and the front end of the sixth lower flange material 16F) are joined with welding means so as to sandwich the joint portion 22B in a vertical direction.

[0063] As a result, the bracket member 22 is provided so that it is located at the front end (the tip) side of the boom 11 and welded between the front ends of the left and right fifth web materials 12E, the front end of the front upper flange material 14B, and the front end of the sixth lower flange material 16F. As shown in Fig. 1, to such a bracket member 22, a base end side of the arm 9 is liftably pin-coupled.

[0064] Indicated at 23 is the other bracket member as the arm cylinder mounting member to which the arm cylinder 9A is coupled. The bracket member 23 is formed as a bifurcated bracket and has a pin through hole 23A. The bracket member 23 is joined to a top face side of the middle upper flange material 14C of the upper flange plate 14 by using means such as fillet welding, for example. To the pin through hole 23A of the bracket member 23, as shown in Fig. 1, a bottom side of the arm cylinder 9A is rotatably pin-coupled.

[0065] Here, as shown in Figs. 2 and 3, when there is a second reference line L2 connecting the centers of the pin through hole 23A of the bracket member 23 and the boss portion 21A of the boss member 21, assume that there is a second orthogonal line B-B orthogonal to the reference line L2. The welding line 13C between the third web material 12C and the adjacent fourth web material 12D is disposed in a range closer to the second orthogonal line B-B in such a way that the welding line 13C is nearly orthogonal to the second reference line L2. An angle θ_2 which the second orthogonal line B-B and the welding line 13C form is set at an angle of 12 degrees or less (for example, $\theta_2 \approx 10.5$ to 11.5 degrees).

[0066] The hydraulic excavator 1 according to the first embodiment has the configuration described above and the operation thereof will be described hereafter.

[0067] The operator who got into the cab 5 of the hydraulic excavator 1 operates a lever, a pedal (none of which is illustrated), and the like in the cab 5 and supplies pressurized oil which is discharged from a hydraulic pump (not shown) in the housing cover 7 to the lower traveling structure 2, thereby driving a traveling motor and the like of the lower traveling structure 2 and moving the vehicle forward and rearward.

[0068] By turning the bucket 10 with the bucket cylinder 10A while moving the boom 11 and the arm 9 upward and downward by making the boom cylinder 11A and the arm cylinder 9A expand and contract by supplying and exhausting the pressurized oil from the hydraulic pump to and from the working mechanism 8 side through supply and exhaust pipe line (not shown), excavation operation of sand and dust and other operations are performed.

[0069] Next, a production process of the boom 11, which forms the working arm of the working mechanism 8 with the arm 9, will be described with reference to Figs. 4 to 9. Here, the left and right web plates 12 and the upper and lower flange plates 14 and 16 which form the boom 11 are produced by press forming in separate processes, respectively.

[Press process and partial welding process]

[0070] In the left and right web plates 12 (in Figs. 4 and 5, one of them is shown), the first to fifth web materials 12A to 12E formed by press forming so as to have different shapes are joined together in a front-rear direction along the welding lines 13A, 13B, 13C, and 13D by butt welding with a V-shaped groove as shown in Fig. 5. In this case, with regard to the first web material 12A, at a stage of press forming before the first web material 12A is joined to the second web material 12B, the first web material 12A is bent in the position of the bending line 12A1 closer to the front side in such a way that the first web material 12A is curved to the outside in a left-right direction.

[0071] In the upper flange plate 14, the rear upper flange material 14A, the middle upper flange material 14C, and the front upper flange material 14B formed by press forming so as to have different shapes are joined together in a front-rear direction along the welding lines 15A and 15B by butt welding with a V-shaped groove. As described above, in a state in which the middle upper flange material 14C is joined between the rear upper flange material 14A and the front upper flange material 14B along the welding lines 15A and 15B, rolling process after joining the plates is performed on the upper flange plate 14. As a result, the rear upper flange material 14A and the middle upper flange material 14C of the upper flange plate 14 are curved into a shape that follows the arc-shaped contour of the upper end side of the web plate 12.

[0072] For the lower flange plate 16, rolling process before joining the plates is performed on the third lower flange material 16C of the first to sixth lower flange materials 16A to 16F formed by press forming so as to have different shapes. As a result, the third lower flange material 16C is curved into a shape that follows the arc-shaped contour of the lower end side of the web plate 12. Then, as shown in Fig. 5, the rear end portion of the fourth lower flange material 16D is integrally joined to the front end portion of the third lower flange material 16C along the welding line 17A by butt welding with a V-shaped groove.

[0073] However, the first lower flange material 16A, the second lower flange material 16B, the joined body of the third and fourth lower flange materials 16C and 16D, the fifth lower flange material 16E, and the sixth lower flange material 16F of the lower flange plate 16 are not joined to one another and are put on standby in predetermined positions until a final stage (a lower flange plate assembly process shown in Fig. 8) of assembly operation of the boom 11 is performed.

[Assembly process of the left and right web plates and the upper flange plate]

[0074] Next, in an assembly process shown in Fig. 6, on an assembling jig 24 which is prepared in advance, the left and right web plates 12 and the upper flange plate 14 are disposed so as to be temporarily joined. In this case, the upper flange plate 14 formed of the rear upper flange material 14A, the front upper flange material 14B, and the middle upper flange material 14C is fixed in such a way as to be temporarily joined to the upper end sides of the left and right web plates 12 by welding. At this time, the welding lines 13A, 13B, 13C, and 13D of the web plates 12 are disposed in positions in which the end portions 13A1, 13B1, 13C1, and 13D1 of the welding lines 13A to 13D and the end portions 15A1 and 15B1 (the end portions 15A2 and 15B2) of the welding lines 15A and 15B appear alternately in a front-rear direction of the boom 11, in such a way that the welded positions of the welding lines 13A to 13D do not overlap the welded positions of the welding lines 15A and 15B of the upper flange plate 14.

[0075] Next, between the left and right web plates 12 and the upper flange plate 14, the first and second partition plates 18 and 19 are disposed so as to be temporarily joined by welding. That is, the first partition plate 18 is temporarily joined between the left and right second web materials 12B and to a rear side of the middle upper flange material 14C by partial welding. The second partition plate 19 is temporarily joined between the left and right fourth web materials 12D and to a front side of the middle upper flange material 14C by partial welding.

[0076] Moreover, to the rear end sides (the rear end sides) of the left and right web plates 12 and the upper flange plate 14 in a front-rear direction, the boss member 20 on the boom foot side is temporarily joined by welding. In a middle part in a length direction, the boss member 21 for the boom cylinder 11A is temporarily joined by welding located between the left and right third web materials 12C. That is, the annular flange portion 21B of the boss member 21 is temporarily joined to the punching holes 12C3 of the third web materials 12C by welding. Next, to the front end sides of the left and right web plates 12 and the upper flange plate 14 in a front-rear direction, the bracket member 22 for the arm 9 is temporarily joined by welding, and, to the top face side of the middle upper flange material 14C, the bracket member 23 for the arm cylinder 9A is temporarily joined by welding.

[0077] In this way, using the assembling jig 24 shown in Fig. 6 produces the boom assembly body 31, which is a preliminary assembly of the boom 11. In this case, the boom assembly body 31 is formed of the left and right web plates 12, the upper flange plate 14, the first and second partition plates 18 and 19, the boss members 20 and 21, and the bracket members 22 and 23 which were integrally assembled by being temporarily joined.

[Internal welding process]

[0078] In an internal welding process shown in Fig. 7, the boom assembly body 31 is set between a prepared pair of rotating positioners 25. Next, the boom assembly body 31 is rotated by the pair of rotating positioners 25 in a direction indicated by an arrow C in Fig. 7, and internal welding is performed on the boom assembly body 31. That is, internal welding over the entire length in a front-rear direction is performed on the joining parts between the left and right web plates 12 and the upper flange plate 14. Internal welding for the first partition plate 18 is performed, by means such as fillet welding, on the joining parts between the first partition plate 18 and the left and right second web materials 12B and the joining part between the first partition plate 18 and the rear side of the middle upper flange material 14C. Also, internal welding for the second partition plate 19 is performed, by means such as fillet welding, on the joining parts between the second partition plate 19 and the left and right fourth web materials 12D and the joining part between the second partition plate 19 and the front side of the middle upper flange material 14C.

[0079] On the other hand, internal welding for the boss member 20 on the boom foot side is performed on the joining parts between the boss member 20 and the left and right first web materials 12A and the joining part between the boss member 20 and the rear upper flange material 14A, and, also internal welding for the boss member 21 for the boom cylinder 11A is performed on the joining parts between the boss member 21 and the left and right third web materials 12C, whereby they are firmly fixed by welding. Internal welding for the bracket member 22 for the arm 9 is performed on the joining parts between the bracket member 22 and the left and right fifth web materials 12E and the joining part between the bracket member 22 and the front upper flange material 14B, whereby they are firmly fixed.

[Lower flange plate assembly process]

[0080] Next, in regard to an assembly process of the lower flange plate 16 shown in Fig. 8, a joined body of the third lower flange material 16C and the fourth lower flange material 16D which were joined together in advance is joined to the left and right web plates 12 of the boom assembly body 31 by welding in such a way as to close partially the lower end side of the middle part thereof in a length direction. At this time, the first partition plate 18 is joined, at the lower end side thereof, to an internal face of the third lower flange material 16C by means such as fillet welding. The second partition plate 19 is also joined, at the lower end side thereof, to the internal face of the third lower flange material 16C by means such as fillet welding.

[0081] Next, the second lower flange material 16B and the sixth lower flange material 16F of the lower flange plate 16 are joined to the left and right web plates 12 by being welded thereto in such a way as to close partially the lower end side thereof. At this time, the rear end portion of the second lower flange material 16B is joined to the front end portion of the third lower flange material 16C along the welding line 17B (see Fig. 9), and, in the position of the welding line 17B, both side welding of the inside and the outside is performed in a state in which they are butted. Moreover, the front end portion of the sixth lower flange material 16F is joined to the joint portion 22B of the bracket member 22 by both side welding of the inside and the outside in a state in which they are butted in a front-rear direction.

[0082] Next, the first lower flange material 16A and the fifth lower flange material 16E are joined to the left and right web plates 12 by being welded thereto in such a way as to close the lower end side thereof, and the assembly operation of the lower flange plate 16 is completed. That is, when the operation to join the first lower flange material 16A and the fifth lower flange material 16E is completed, the lower end side of the left and right web plates 12 is practically closed over the entire length thereof in a front-rear direction.

[0083] At this time, the rear end portion of the first lower flange material 16A is joined to the front end portion of the second lower flange material 16B along the welding line 17C (see Fig. 9). Incidentally, in the position of the welding line 17C, butt welding with a V-shaped groove using a backing material (not shown) is performed in an external welding process which will be described later. On the other hand, the rear end portion of the fifth lower flange material 16E is joined to the front end portion of the fourth lower flange material 16D along the welding line 17D, and the front end portion of the fifth lower flange material 16E is joined to the rear end portion of the sixth lower flange material 16F along the welding line 17E. Also, in this case, in the positions of the welding lines 17D and 17E, butt welding with a V-shaped groove using a backing material (not shown) is performed in the external welding process which will be described later.

[External welding process]

[0084] Next, as shown in Fig. 9, external welding which is a final stage of the welding process is performed by using a plurality of welding robots 26. In the external welding process, fillet welding is performed, by the welding robots 26, between the left and right web plates 12 and the upper flange plate 14 over the entire length in a front-rear direction. Likewise, fillet welding is also performed between the left and right web plates 12 and the lower flange plate 16 over the entire length in a front-rear direction. On the other hand, to the top face side of the middle upper flange material 14C of the upper flange plate 14, the bracket member 23 which was temporarily joined thereto in advance is joined more firmly by fillet welding.

[0085] In the external welding process using the welding robots 26, the rear end portion of the first lower flange material 16A and the front end portion of the second lower flange material 16B are joined together along the welding line 17C, and, in the position of the welding line 17C, butt welding with a V-shaped groove using a backing material (not shown) is completed. On the other hand, the rear end portion of the fifth lower flange material 16E and the front end portion of the fourth lower flange material 16D are also joined together along the welding line 17D, and the front end portion of the fifth lower flange material 16E and the rear end portion of the sixth lower flange material 16F are also joined together along the welding line 17E. Also, in the positions of the welding lines 17D and 17E, butt welding with a V-shaped groove using a backing material (not shown) is completed.

[0086] As described above, with the external welding process using the welding robots 26, the boom 11 is completed as a welded structure formed as a long box shape structural body. Then, the boom 11 is transferred to an assembly process of the working mechanism 8 and is assembled with the arm 9 as the working arm of the working mechanism 8 shown in Fig. 1, for example.

[0087] Thus, according to the first embodiment, the left and right web plates 12 of the boom 11 can be formed by joining a total of five web materials such as the first to fifth web materials 12A to 12E having different shapes at the edges in a front-rear direction along the welding lines 13A to 13D. The upper flange plate 14 can be formed by joining a total of three flange materials such as the rear upper flange material 14A, the front upper flange material 14B, and the middle upper flange material 14C having different shapes at the edges in a front-rear direction along the welding lines 15A and 15B. Furthermore, the lower flange plate 16 can be formed by joining a total of six flange materials such as the first to sixth lower flange materials 16A to 16F having different shapes at the edges in a front-rear direction along the welding lines 17A to 17E.

[0088] By using the left and right web plates 12, the upper flange plate 14, and the lower flange plate 16, the boom 11 formed as a box shape structural body, which is quadrangular in cross section, is formed. At this time, the end portions 13A1, 13B1, 13C1, and 13D1 located in the upper parts of the welding lines 13A to 13D between the plate materials forming the left and right web plates 12 can be disposed in positions which are different, in a front-rear direction, from the positions of the end portions 15A1 and 15B1 (the end portions 15A2 and 15B2) of the welding lines 15A and 15B between the plate materials forming the upper flange plate 14. Likewise, the end portions 13A2, 13B2, 13C2, and 13D2 located in the lower parts of the welding lines 13A to 13D can be disposed in positions which are different, in a front-rear direction, from the positions of the end portions 17A1, 17B1, 17C1, 17D1, and 17E1 (the end portions 17A2, 17B2,

17C2, 17D2, and 17E2) of the welding lines 17A to 17E between the plate materials forming the lower flange plate 16.

[0089] As a result, since it is possible to prevent overlapping of the welding line end portions at which welding defects easily occur, it is possible to reduce the possibility of the occurrence of welding defects and produce the boom 11 with a high-strength welding structure. Furthermore, it is possible to reduce the plate thicknesses of the plate materials forming the boom 11 to a requisite minimum and achieve reduction in weight by reducing the weight of the boom 11 as a whole. In addition, it is possible to increase impact resistance of the boom 11 to the excavation reaction force or the like and ensure sufficient bending strength and torsional strength.

[0090] Of the left and right web plates 12 forming the boom 11, the first web material 12A to which the boss member 20 on the boom foot side is joined and the third web plate 12C located in the middle-most in a front-rear direction use a thick plate material. The other web materials such as the second web material 12B, the fourth web material 12D, and the fifth web material 12E can use a material whose plate thickness is smaller than those of the first web material 12A and the third web material 12C.

[0091] As a result, the first web materials 12A can support the boss member 20 on the boom foot side with a solid structure with the rear upper flange material 14A of the upper flange plate 14 and the first lower flange material 16A of the lower flange plate 16 and increase the support strength on the boom foot side. The left and right third web materials 12C can support the boss member 21 to which the rod side of the boom cylinder 11A is rotatably pin-coupled with a solid structure and increase the support strength for the boom cylinder 11A.

[0092] On the other hand, as shown in Fig. 3, of a total of five plate materials forming each of the left and right web plates 12, the third web material 12C can dispose the welding line 13B along which it is joined to the edge of the second web material 12B in a position near the orthogonal line A-A orthogonal to the first reference line L1. This makes it possible to increase the joint strength, that is, the welding strength in a position along the welding line 13B between the second web material 12B and the third web material 12C to the stress that is produced in the left and right web plates 12 between the boss member 21 and the boss member 20 on the boom foot side by the expanding and contracting operation and the like of the boom cylinder 11A and increase welding life and reliability.

[0093] Moreover, the third web material 12C can dispose the welding line 13C along which it is joined to the edge of the fourth web material 12D in a position near the orthogonal line B-B orthogonal to the second reference line L2. This makes it possible to increase the joint strength, that is, the welding strength in a position along the welding line 13C between the third web material 12C and the fourth web material 12D to the stress that is produced in the left and right web plates 12 between the boss member 21 and the bracket member 23 by the expanding and contracting operation of the arm cylinder 9A, the expanding and contracting operation of the boom cylinder 11A, and the like, and increase welding life and reliability.

[0094] In addition, of the left and right web plates 12 each being formed of the first to fifth web materials 12A to 12E, between the second web materials 12B, the first partition plate 18 can be provided by being joined between the upper and lower flange plates 14 and 16 by welding, and the first partition plate 18 can increase the joint strength by welding between the left and right web plates 12 and the upper and lower flange plates 14 and 16. Moreover, between the left and right fourth web materials 12D, the second partition plate 19 can be provided by being joined between the upper and lower flange plates 14 and 16 by welding, and the second partition plate 19 can increase the joint strength by welding between the left and right web plates 12 and the upper and lower flange plates 14 and 16.

[0095] Therefore, according to the first embodiment, the left and right web plates 12 and the upper and lower flange plates 14 and 16 can be formed by using a plate material with a requisite minimum plate thickness, which makes it possible to reduce the cost of material and reduce the weight of the boom 11 as a whole. This makes it possible to form the boom cylinder 11A as a smaller hydraulic cylinder. Furthermore, it is possible to reduce the inertial force exerted when the boom 11 is moved upward and downward by the boom cylinder 11A and improve the positioning performance and the like when the boom 11 is stopped in a desired position.

[0096] Next, Fig. 10 shows a second embodiment of the present invention. A feature of the second embodiment is that a left web plate and a right web plate are each formed of a total of six plate materials, an upper flange plate is formed of a total of four plate materials, and a lower flange plate is formed of a total of seven plate materials. Incidentally, in the second embodiment, the component elements that are identical to those of the foregoing first embodiment will be simply denoted by the same reference numerals to avoid repetitions of similar explanations.

[0097] In the drawing, designated at 41 is a boom adopted in the second embodiment, and the boom 41 is formed in substantially the same way as the boom 11 described in the first embodiment. The boom 41 is formed of a pair of left and right web plates 42 and 42 extending in a length direction (a front-rear direction) thereof and facing each other in a left-right direction and upper and lower flange plates 43 and 44 joined to the upper and lower end sides of the web plates 42 by welding, respectively, and the boom 41 is formed as the box shape structural body being a closed section structure which is quadrangular in cross section.

[0098] However, the left and right web plates 42 differ from the first embodiment in that the left and right web plates 42 are each formed of a total of six plate materials. That is, the web plate 42 is formed of a total of six plate materials such as first to fourth web materials 42A to 42D which are formed in the same way as the first to fourth web materials

12A to 12D described in the first embodiment, a fifth web material 42E, and a sixth web material 42F. Here, the fifth web material 42E and the sixth web material 42F are formed by dividing the fifth web material 12E described in the form of the above-mentioned first embodiment into two plate materials. The fifth web material 42E is joined, at the front end thereof, to a rear end side of the sixth web material 42F along a welding line (not shown).

[0099] As is the case with the first web material 12A described in the first embodiment, the first web material 42A of the web plate 42 is bent in the position of a bending line 42A1 closer to the front side in such a way that the first web material 42A is curved to the outside in a left-right direction. Furthermore, as is the case with the third web material 12C described in the first embodiment, both upper and lower end sides of the third web material 42C are arc-shaped edge portions 42C1 and 42C2, and, between the edge portions 42C1 and 42C2, a circular punching hole 42C3 is formed to which an annular flange portion 21B of a boss member 21 is joined by welding.

[0100] On the other hand, the upper flange plate 43 differs from the first embodiment in that the upper flange plate 43 is formed of a total of four plate materials. That is, the upper flange plate 43 is formed of a total of four plate materials, a first upper flange material 43A located on the rear end side of the entire length of the upper flange plate 43, a second upper flange material 43B located in front of the first upper flange material 43A, a third upper flange material 43C located in front of the second upper flange material 43B, and a fourth upper flange material 43D located in front of the third upper flange material 43C.

[0101] Here, the first upper flange material 43A is formed in the same way as the rear upper flange material 14A described in the first embodiment, and the second upper flange material 43B is formed in the same way as the middle upper flange material 14C described in the first embodiment. However, the third upper flange material 43C and the fourth upper flange material 43D are formed by dividing the front upper flange material 14B described in the form of the above-mentioned first embodiment into two plate materials. The front end of the third upper flange material 43C is joined to the rear end of the fourth upper flange material 43D along a welding line (not shown).

[0102] The lower flange plate 44 differs from the first embodiment in that the lower flange plate 44 is formed of a total of seven plate materials. That is, the lower flange plate 44 is formed of a total of seven plate materials, first to fourth lower flange materials 44A to 44D formed in the same way as the first to fourth lower flange materials 16A to 16D described in the first embodiment, a fifth lower flange material 44E, a sixth lower flange material 44F, and a seventh lower flange material 44G.

[0103] Here, the fifth lower flange material 44E and the sixth lower flange material 44F of the lower flange plate 44 are formed by dividing the fifth lower flange material 16E of the lower flange plate 16 described in the form of the above-mentioned first embodiment into two plate materials, and, in this respect, this embodiment differs from the form of the first embodiment. The front end of the fifth lower flange material 44E is joined to the rear end of the sixth lower flange material 44F along a welding line (not shown). On the other hand, the seventh lower flange material 44G of the lower flange plate 44 is formed in the same way as the sixth lower flange material 16F of the lower flange plate 16 described in the form of the above-mentioned first embodiment.

[0104] Moreover, the end portions of the welding lines between the first to sixth web materials 42A to 42F forming the left and right web plates 42 and the end portions of the welding lines between the first to fourth upper flange materials 43A to 43D forming the upper flange plate 43 are disposed in positions that are different from one another in a front-rear direction. Furthermore, the end portions of the welding lines between the first to sixth web materials 42A to 42F forming the left and right web plates 42 and the end portions of the welding lines between the first to seventh lower flange materials 44A to 44G forming the lower flange plate 44 are disposed in positions that are different from one another in a front-rear direction.

[0105] Thus, also in the second embodiment configured as described above, the left and right web plates 42 and the upper and lower flange plates 43 and 44 can be formed by using a plate material with a requisite minimum plate thickness, making it possible to produce almost the same advantage as that in the first embodiment.

[0106] In the above-described second embodiment, it is explained by citing as an example the case in which the left and right web plates 42 are each formed of six plate materials, the upper flange plate 43 is formed of four plate materials, and the lower flange plate 44 is formed of seven plate materials. However, the present invention is not limited to the same; for example, the left and right web plates may be each formed of seven plate materials, the upper flange plate may be formed of three plate materials, and the lower flange plate may be formed of six plate materials. On the other hand, the left and right web plates may be each formed of five plate materials, the upper flange plate may be formed of four plate materials, for example, and the lower flange plate may be formed of six plate materials. Moreover, a configuration may be adopted in which the left and right web plates are each formed of five plate materials, the upper flange plate is formed of four plate materials, and the lower flange plate is formed of six plate materials. That is, according to the present invention, it is necessary simply to adopt a configuration in which the left and right web plates are each formed of at least five plate materials, the upper flange plate is formed of at least three plate materials, and the lower flange plate is formed of at least six plate materials.

[0107] Furthermore, in the above-described embodiment, it is explained by citing as an example the case in which the boom 11 provided in the hydraulic excavator 1 as a typical example of the construction machine. However, the

present invention is not limited to the same and can be applied to a boom as a working arm used in other construction machines such as a wheel hydraulic excavator.

DESCRIPTION OF REFERENCE NUMERALS

5

[0108]

	1:	Hydraulic excavator (Construction machine)
10	8:	Working mechanism
	11, 41:	Boom
	12, 42:	Web plate
15	12A, 42A:	First web material (Plate material on the rear end side)
	12B, 42B:	Second web material (Plate material)
20	12C, 42C:	Third web material (Plate material located in the middle)
	12D, 42D:	Fourth web material (Plate material)
	12E, 42E:	Fifth web material (Plate material)
25	13A to 13D:	Welding lines of a web plate
	13A1, 13B1, 13C1, 13D1:	End portion
30	13A2, 13B2, 13C2, 13D2:	End portion
	14, 43:	Upper flange plate
	14A:	Rear upper flange material (Plate material)
35	14B:	Front upper flange material (Plate material)
	14C:	Middle upper flange material (Plate material)
40	15A, 15B:	Welding line of an upper flange plate
	15A1, 15B1, 15A2, 15B2:	End portion
	16, 44:	Lower flange plate
45	16A to 16F, 44A to 44F:	First to sixth lower flange materials (Plate materials)
	17A to 17E:	Welding lines of a lower flange plate
50	17A1, 17B1, 17C1, 17D1, 17E1:	End portion
	17A2, 17B2, 17C2, 17D2, 17E2:	End portion
	18:	First partition plate
55	19:	Second partition plate
	20:	Boss member (Boom foot-side mounting member)

21:	Boss member (Boom cylinder mounting member)
22:	Bracket member (Arm-side mounting member)
5 23:	Bracket member (Arm cylinder mounting member)
24:	Assembling jig
31:	Boom assembly body
10 42F:	Sixth web material
43A to 43D:	First to fourth upper flange materials (Plate materials)
15 44G:	Seventh lower flange material (Plate material)

Claims

20 1. A boom for a construction machine, comprising:

left and right web plates (12, 42);
an upper flange plate (14, 43) that is joined to upper end sides of said left and right web plates (12, 42) by
welding; and
25 a lower flange plate (16, 44) that is joined to lower end sides of said left and right web plates (12, 42) by welding,
said boom is formed of said left and right web plates (12, 42) and said upper and lower flange plates (14, 43),
(16, 44), and formed as the box shape structural body being a closed section structure which is quadrangular
in cross section, **characterized in that**;
said left web plate (12, 42) and said right web plate (12, 42) are each formed by joining a total of at least five
30 plate materials (12A to 12E, 42A to 42F) having different shapes at edge portions in a front-rear direction along
welding lines (13A to 13D),
said upper flange plate (14, 43) is formed by joining a total of at least three plate materials (14A to 14C, 43A to
43D) having different shapes at edge portions in a front-rear direction along welding lines (15A, 15B),
said lower flange plate (16, 44) is formed by joining a total of at least six plate materials (16A to 16F, 44A to
35 44G) having different shapes at edge portions in a front-rear direction along welding lines (17A to 17E),
end portions (15A1, 15B1, 15A2, 15B2) of said welding lines (15A, 15B) between said plate materials (14A to
14C, 43A to 43D) forming said upper flange plate (14, 43) and end portions (13A1 to 13D1, 13A2 to 13D2) of
said welding lines (13A to 13D) between said plate materials (12A to 12E, 42A to 42F) forming said left and
right web plates (12, 42) are disposed in positions that are different from one another in a front-rear direction, and
40 end portions (17A1 to 17E1, 17A2 to 17E2) of said welding lines (17A to 17E) between said plate materials
(16A to 16F, 44A to 44G) forming said lower flange plate (16, 44) and said end portions (13A1 to 13D1, 13A2
to 13D2) of said welding lines (13A to 13D) between said plate materials (12A to 12E, 42A to 42F) forming said
left and right web plates (12, 42) are disposed in positions that are different from one another in a front-rear
direction.

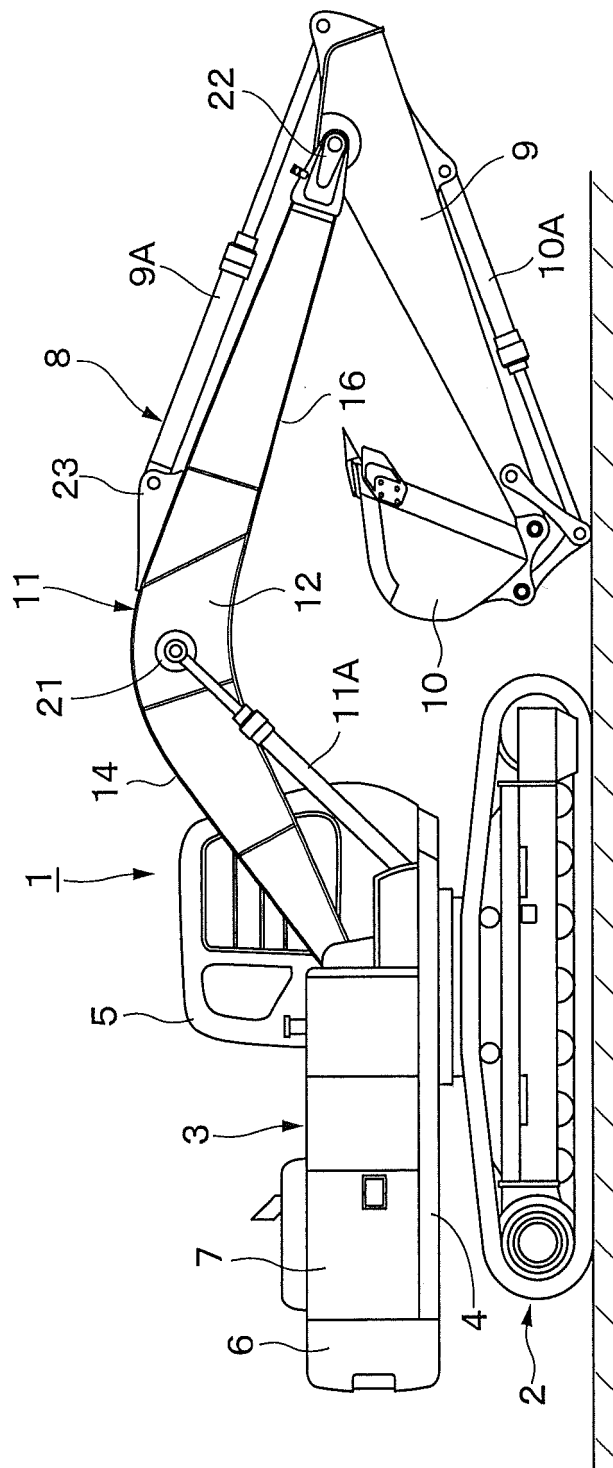
45 2. The boom for the construction machine according to claim 1, wherein a boom foot-side mounting member (20) that
is located on a rear end side in a front-rear direction and is welded between said upper and lower flange plates (14,
16), and a boom cylinder mounting member (21) that is welded to said plate material (12C) located in the middle-
most of said five plate materials (12A to 12E) in a front-rear direction and a boom cylinder (11A) is rotatably coupled
50 thereto, are provided between said left and right web plates (12), and
of said five plate materials (12A to 12E) forming said left and right web plates (12), the plate thicknesses of said
plate material (12A) on the rear end side to which said boom foot-side mounting member (20) is welded, and said
plate material (12C) located in the middle are made greater than the plate thicknesses of the other three plate
materials (12B, 12D, 12E).

55 3. The boom for the construction machine according to claim 1, wherein a boom foot-side mounting member (20) that
is located on a rear end side in a front-rear direction and is welded between said upper and lower flange plates (14,
16), and a boom cylinder mounting member (21) that is welded to said plate material (12C) located in the middle-

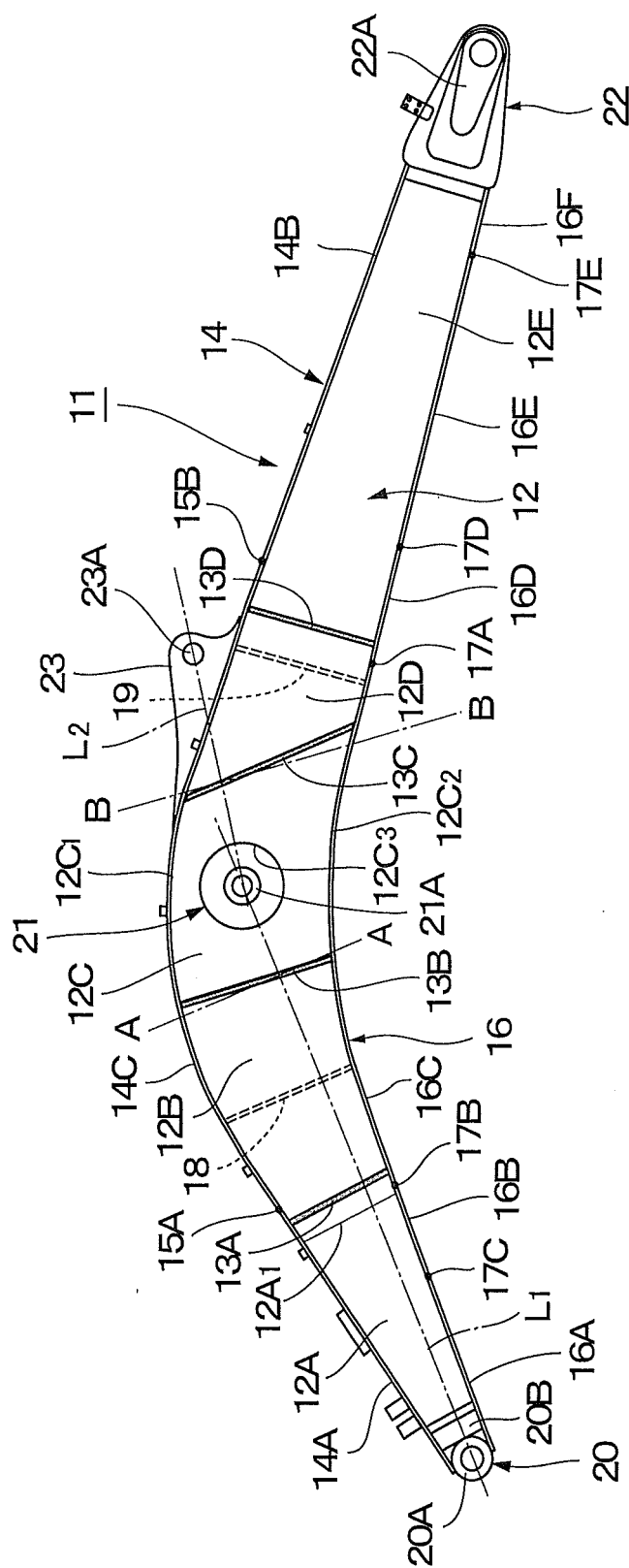
most of said five plate materials (12A to 12E) in a front-rear direction and a boom cylinder (11A) is rotatably coupled thereto, are provided between said left and right web plates (12),
 an arm cylinder mounting member (23) which is located in a position closer to a front side than said boom cylinder mounting member (21) and in a top face of said plate material (14C) located in the middle of said three plate materials (14A to 14C), and an arm cylinder (9A) is rotatably coupled thereto, is provided in said upper flange plate (14), and
 in said plate material (12C) located in the middle of each of said left and right web plates (12), said welding line (13B) on a rear side in a front-rear direction is disposed so as to be nearly orthogonal to a first reference line (L1) connecting said boom foot-side mounting member (20) and said boom cylinder mounting member (21) and said welding line (13C) on a front side in a front-rear direction is disposed so as to be nearly orthogonal to a second reference line (L2) connecting said boom cylinder mounting member (21) and said arm cylinder mounting member (23) .

4. The boom for the construction machine according to claim 1, wherein said left and right web plates (12) are each formed of a total of five plate materials (12A to 12E), such as, a first web material (12A) located on a rear end side in a front-rear direction, a second web material (12B) whose rear end portion is joined to a front end portion of said first web material (12A), a third web material (12C) whose rear end portion is joined to a front end portion of said second web material (12B), a fourth web material (12D) whose rear end portion is joined to a front end portion of said third web material (12C), and a fifth web material (12E) whose rear end portion is joined to a front end portion of said fourth web material (12D), and
 between said second web materials (12B) forming said left and right web plates (12), a first partition plate (18) is provided so as to be located between said upper and lower flange plates (14, 16), and, between said fourth web materials (12D), a second partition plate (19) is provided so as to be located between said upper and lower flange plates (14, 16).
5. The boom for the construction machine according to claim 1, wherein an arm-side mounting member (22) that is located on a front end side in a front-rear direction and is welded between said upper and lower flange plates (14, 43), (16, 44) is provided in said left and right web plates (12, 42).

Fig.1



2001



၆၀
-
၆၁

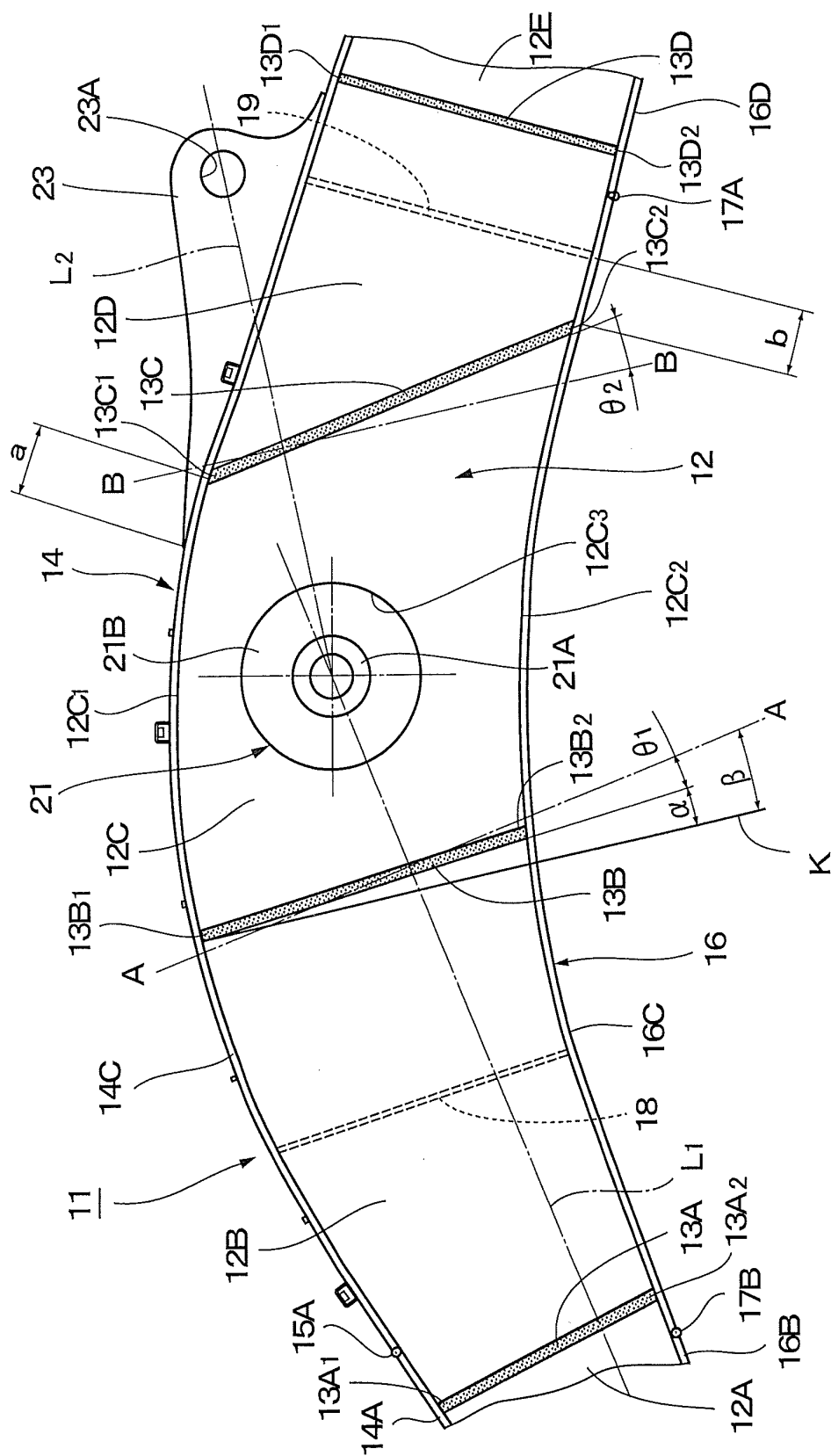


Fig. 4

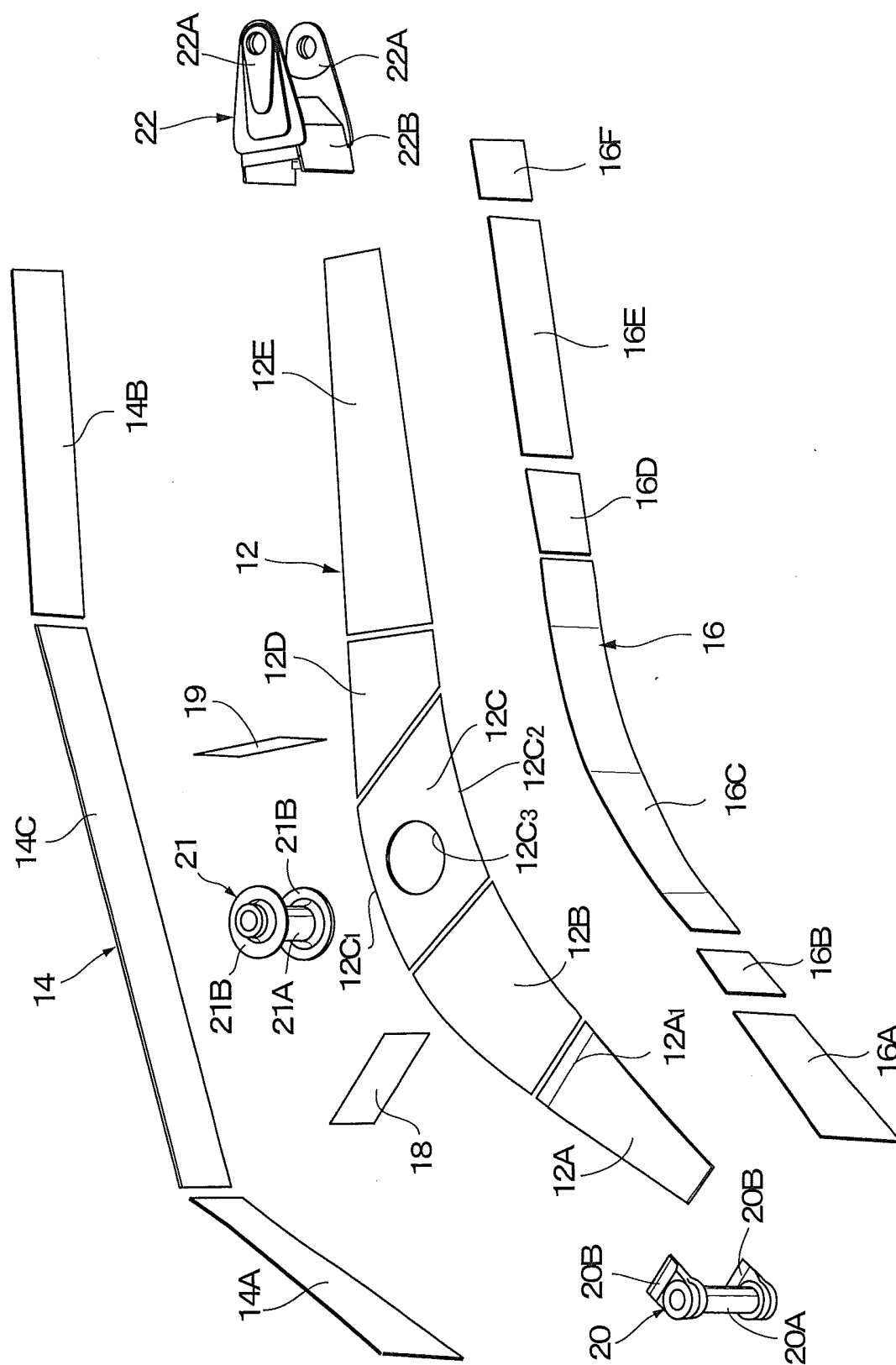
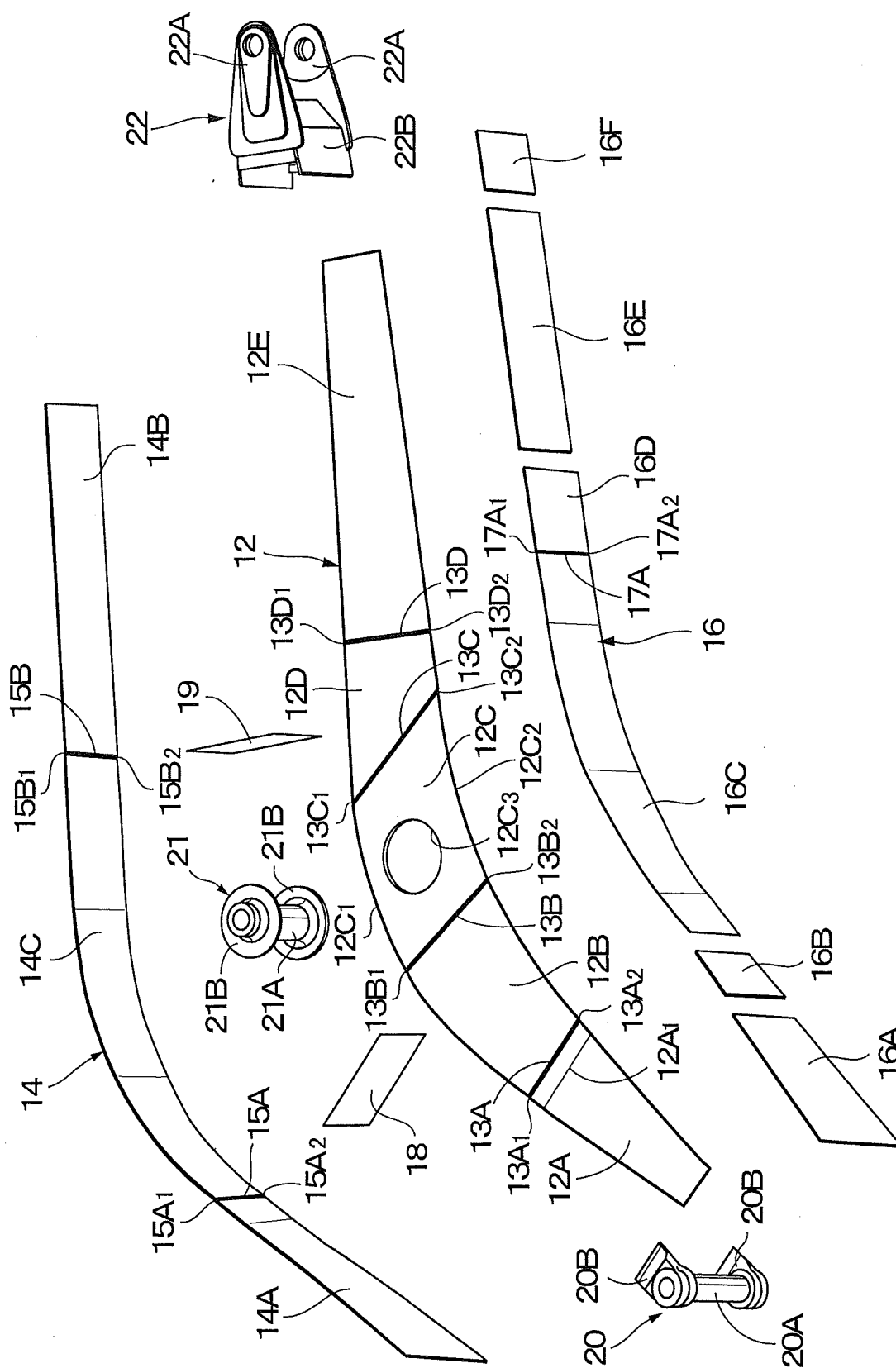
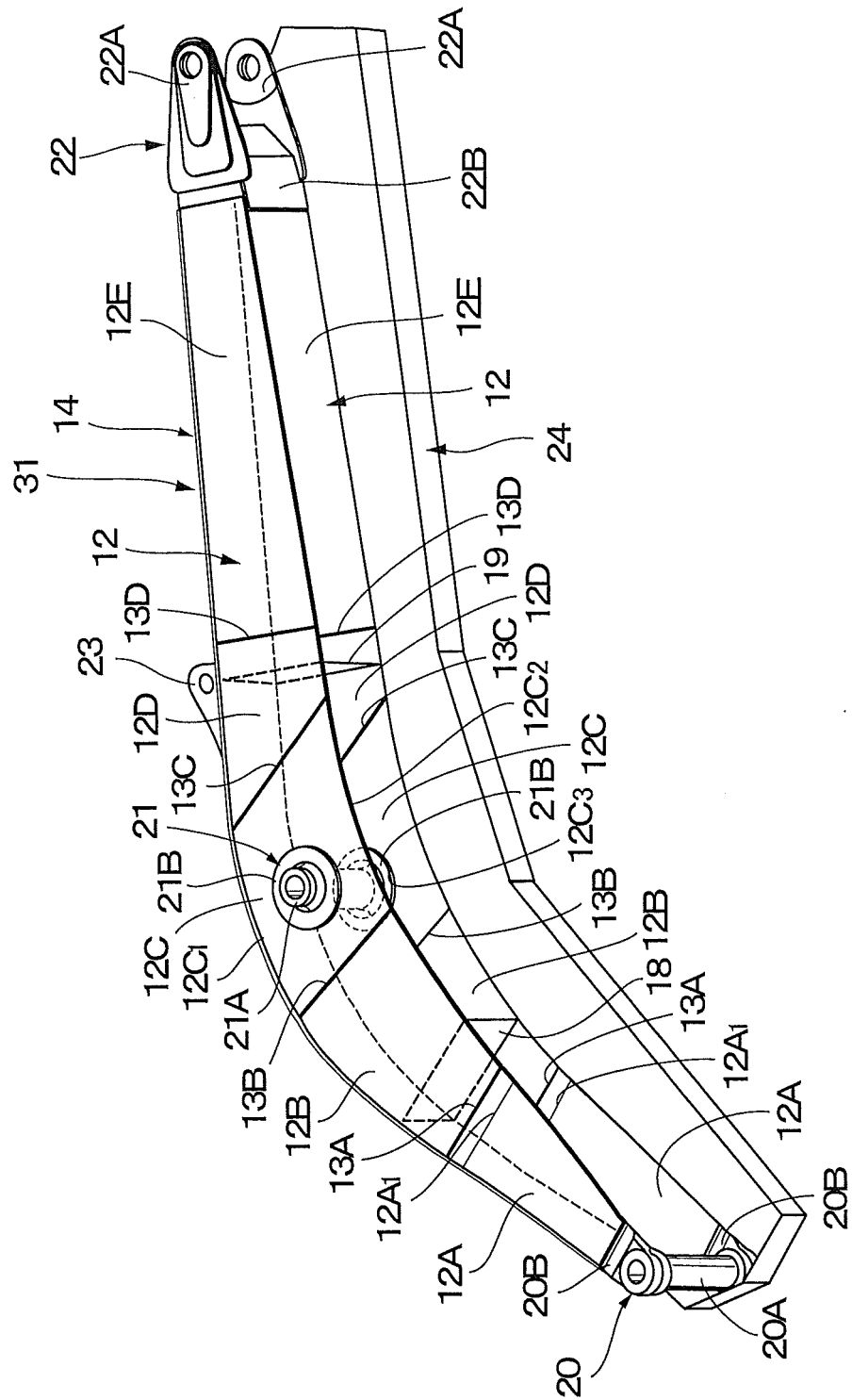


Fig. 5



၆၀
၆၁
၆၂
၆၃



Fi 8.7

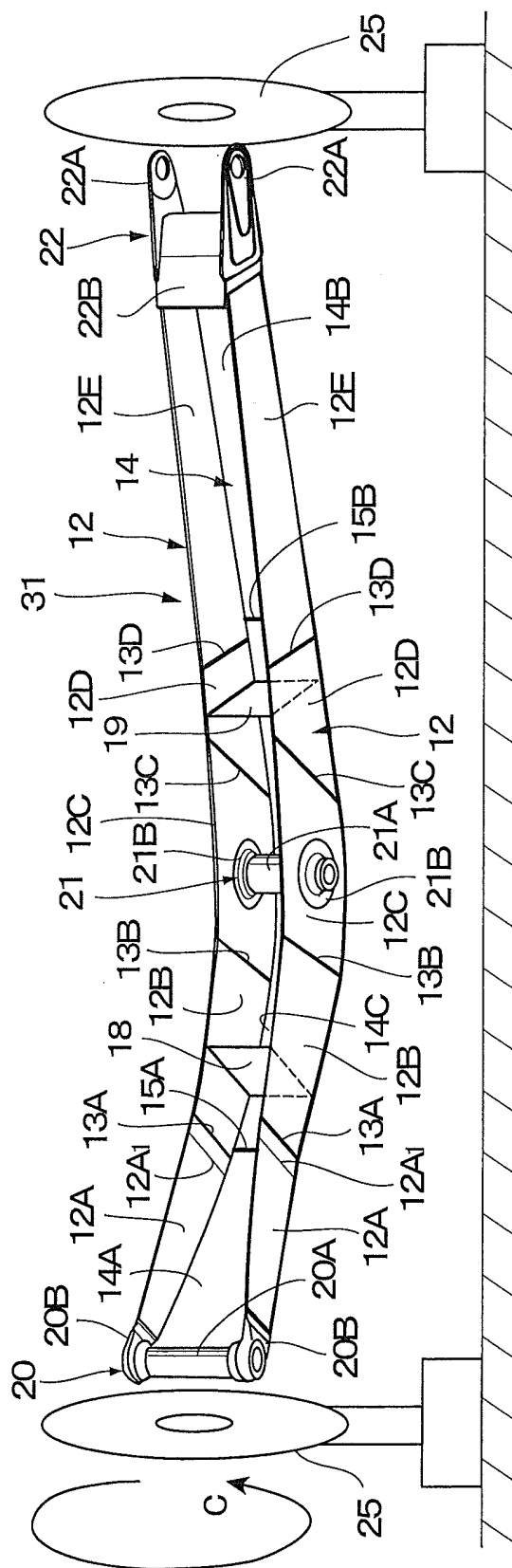


Fig. 8

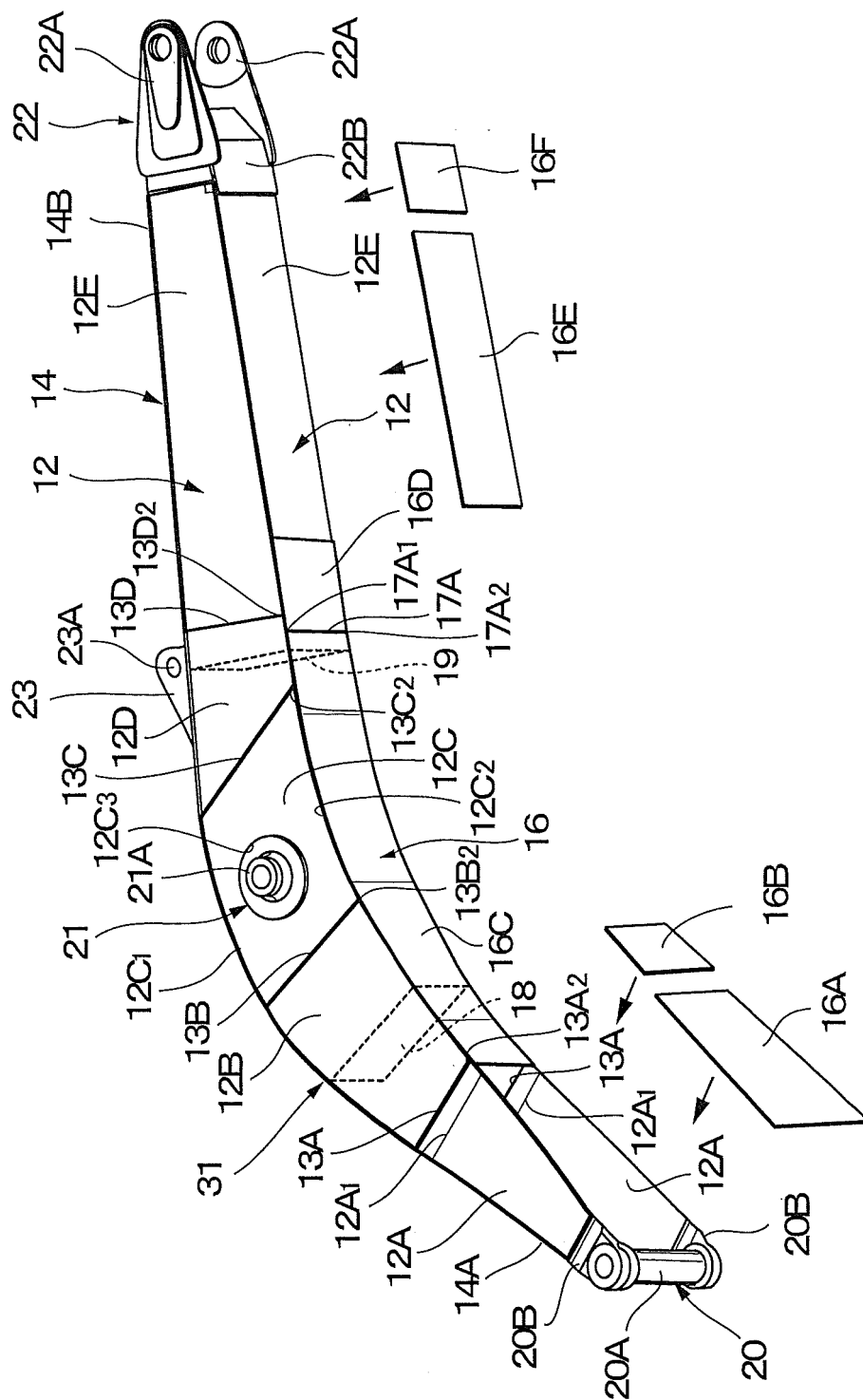
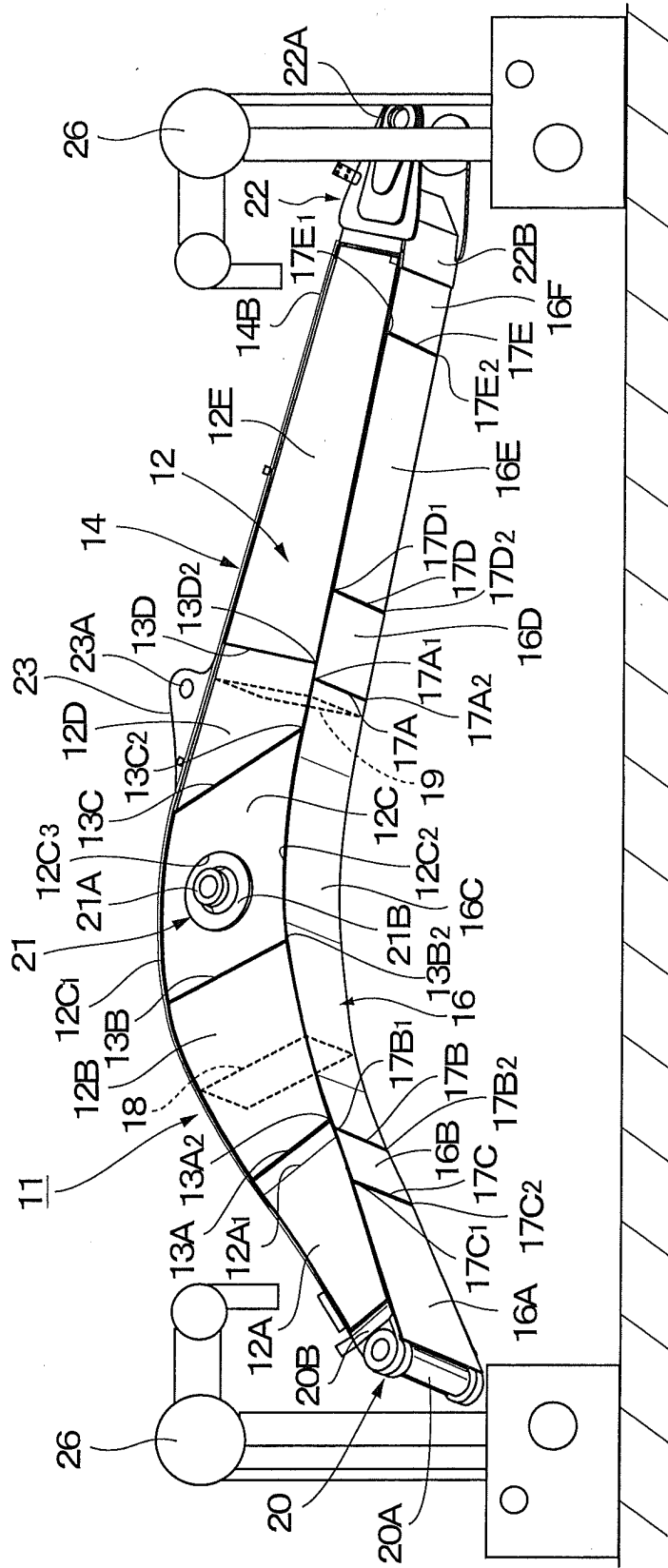
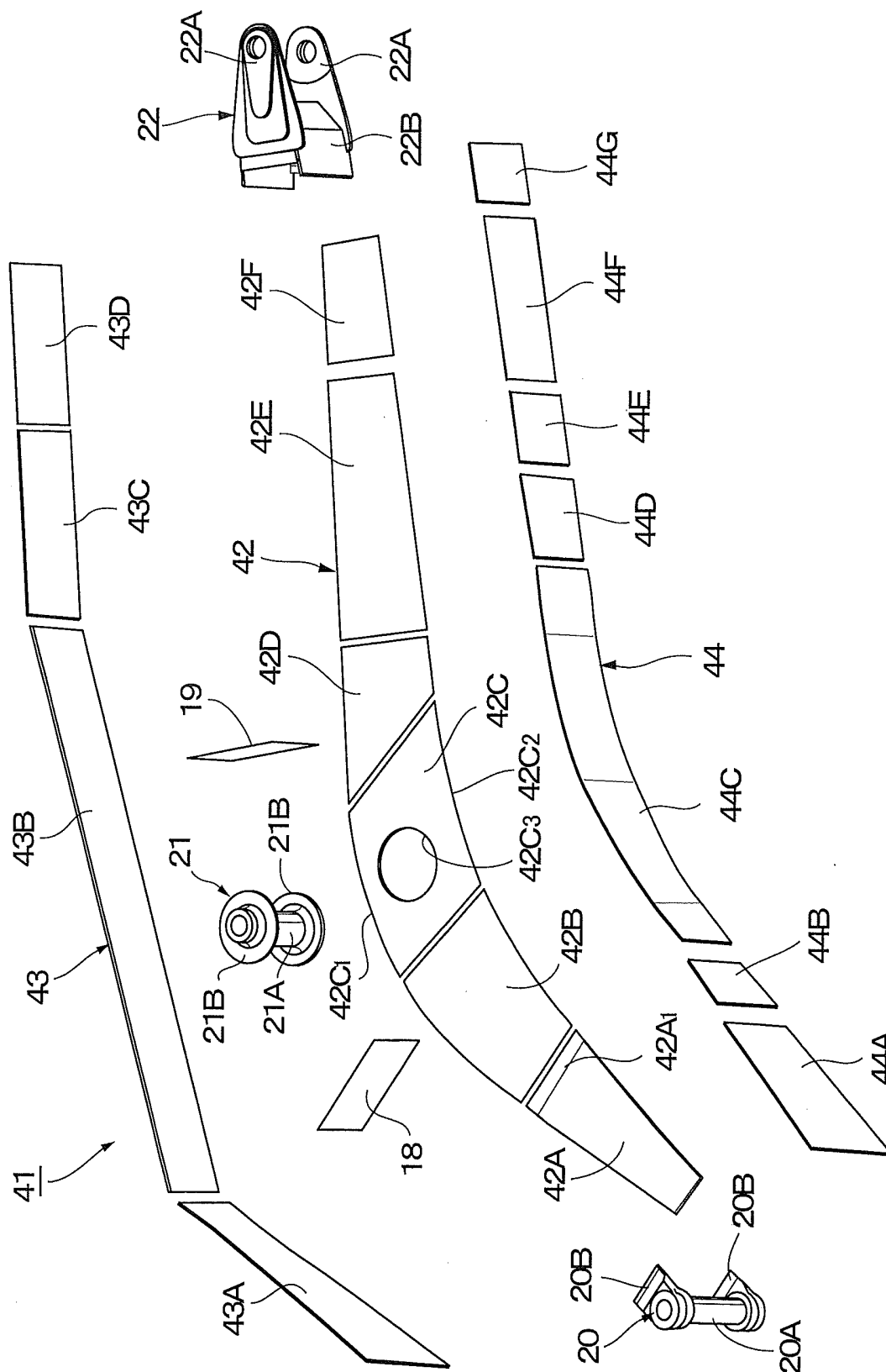


Fig. 9



Fi 10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/059748

A. CLASSIFICATION OF SUBJECT MATTER

E02F3/38(2006.01) i

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)

E02F3/38

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-150775 A (Sumitomo Construction Machinery Co., Ltd.), 08 July 2010 (08.07.2010), entire text; all drawings (Family: none)	1-5
A	JP 2009-148808 A (Hitachi Construction Machinery Co., Ltd.), 09 July 2009 (09.07.2009), entire text; all drawings (Family: none)	1-5
A	JP 2005-029984 A (Hitachi Construction Machinery Co., Ltd.), 03 February 2005 (03.02.2005), entire text; all drawings (Family: none)	1-5



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 July, 2011 (13.07.11)

Date of mailing of the international search report

26 July, 2011 (26.07.11)

Name and mailing address of the ISA/

Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP SHO6111329 Y [0005]