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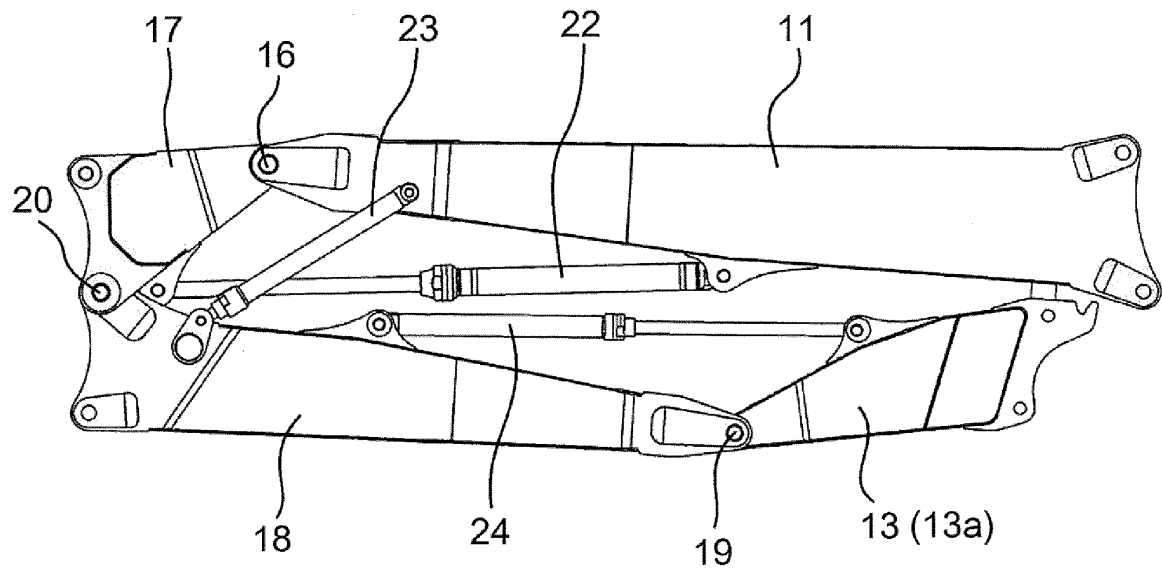
(54) **WORK MACHINE**

(57) There is provided a work machine in which the transportation height of a front device having a boom, a middle arm, and an arm can be reduced, and the working range of the front device can be widened to improve working efficiency. The middle arm 12, which is a constituent member of the front device 4, is bisected into a first middle arm 17 and a second middle arm 18, wherein the first middle arm 17 is rotatably connected to the tip side of an upper boom 11 and has one end part of a middle arm cylinder 22 attached thereto, and the second middle arm 18 is rotatably connected to the rear end side of an arm

13 and has one end part of an arm cylinder 24 attached thereto. The first middle arm 17 and the second middle arm 18 are connected to each other at two locations by an inner pivot pin 20 that is prevented from falling out and an extractable outer connection pin 21. When the connection pin 21 is extracted from the first middle arm 17 and the second middle arm 18, the second middle arm 18 rotates around the pivot pin 20 to be folded with respect to the first middle arm 17.

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FIG. 8



Description

TECHNICAL FIELD

[0001] The present invention relates to a work machine such as a hydraulic excavator, and relates specifically to a work machine including a front device for demolition work.

BACKGROUND ART

[0002] With respect to a hydraulic excavator as a representative example of the work machine, the vehicle body is configured of a self-propelling undercarriage and an upper structure swingably mounted on the upper part of the undercarriage, and a front device is arranged on the front side of the upper structure so as to be rotatable in the vertical direction, the upper structure configuring the vehicle body. Also, when a structure with a large height above the ground level such as a high-rise construction is to be demolished for example, the hydraulic excavator is used with a front device for demolishing work attached on the front side of the upper structure.

[0003] Usually, the front device for demolishing work includes plural number of booms called a multi-boom, and the multi-boom is configured of a lower boom, a middle boom, and an upper boom, the lower boom being rotatably attached to the front part of the upper structure, the middle boom being attached to the tip side of the lower boom, and the upper boom being attached to the tip side of the middle boom. Also, it is configured that the middle arm is rotatably connected to the tip side of the upper boom, an arm is rotatably connected to the tip side of the middle arm, and a working tool such as a crusher is attached to the tip side of the arm. Further, a boom cylinder is attached between the lower boom and the upper structure, and it is configured that the front device is elevated and depressed by extension and contraction of the boom cylinder.

[0004] When the hydraulic excavator including such front device for demolishing work is to be transported to a working site, usually, the hydraulic excavator is divided into the vehicle body and the front device by detaching the front device from the upper structure, and these vehicle body and front device are mounted on transportation vehicles such as a trailer, and are transported to the working site separately. Also, at the working site, by assembling the front device to the vehicle body (the upper structure) of the hydraulic excavator, demolishing work and the like for the structure with a large height above the ground level is executed using this front device (refer to Patent Literature 1 for example).

[0005] Here, since the front device for demolishing work is mounted on a transportation vehicle with an attitude of folding the multi-boom and the arm into a C-shape, the multi-boom and the arm being link-joined to each other with the middle arm located in between, in order that the height during such transportation comes

within the height limitation of the laws and regulations, the length of the middle arm is set to be sufficiently short with respect to the length of the arm.

5 CITATION LIST

PATENT LITERATURE

[0006] PATENT LITERATURE 1: Japanese Patent Application Laid-Open No. 2011-256626

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0007] However, according to the hydraulic excavator of a prior art disclosed in Patent Literature 1 and the like, there has been such problem that, since the longish arm is connected to the tip side of the shortish middle arm, the working range defined by a locus of the arm tip side around the rear end part of the middle arm and a locus of the arm tip side around the tip part of the middle arm becomes narrow, and the operation region of the working tool attached to the tip side of the arm is restricted largely.

[0008] Further, although the working range is widened and the working efficiency can be improved when the middle arm is made longer to shorten the length of the arm just as much, in such case, the height during transportation comes to exceed the height limitation of the laws and regulations because of the middle arm having been elongated. That is to say, since the front device is transported in an attitude of folding the multi-boom and the arm into a C-shape with the middle arm located in between, when the length of the middle arm becomes longer, the transportation height grows just as much. As a result, it is required to transport the front device in a state of disintegrating into each component, and another problem occurs that disintegration work must involve much time and labor.

[0009] The present invention has been achieved from such circumstances of the prior art, and the object thereof is to provide a work machine capable of reducing the transportation height of a front device including a boom, a middle arm, and an arm, and capable of widening the work range of the front device to improve the working efficiency.

SOLUTION TO PROBLEM

[0010] In order to achieve the object described above, a work machine of the present invention is a work machine including a self-propelling vehicle body, a boom attached to the vehicle body so as to be capable of elevated and depressed motions, a middle arm rotatably connected to a tip side of the boom, an arm rotatably connected to the tip side of the middle arm, a working tool attached to the tip side of the arm, a boom cylinder attached between the vehicle body and the boom, a mid-

dle arm cylinder attached between the boom and the middle arm, and an arm cylinder attached between the middle arm and the arm, in which the middle arm is bisected into a first middle arm and a second middle arm, the first middle arm being rotatably connected to the tip side of the boom, one end part of the middle arm cylinder being attached to the first middle arm, the second middle arm being rotatably connected to a rear end side of the arm, and one end part of the arm cylinder being attached to the second middle arm, the first middle arm and the second middle arm are connected to each other at two positions by an inner pivot pin and an outer connection pin, the pivot pin being prevented from falling out, the connection pin being extractable, and when the connection pin is extracted from the first middle arm and the second middle arm, the second middle arm rotates around the pivot pin to be folded with respect to the first middle arm.

ADVANTAGEOUS EFFECTS OF INVENTION

[0011] According to the work machine of the present invention, it is allowed to reduce the transportation height of a front device including a boom, a middle arm, and an arm and to widen the work range of the front device to improve the working efficiency. Problems, configurations, and effects other than those described above will be clarified by explanation of embodiments described below.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

[FIG. 1] FIG. 1 is a side view which shows a hydraulic excavator related to a first embodiment of the present invention.

[FIG. 2] FIG. 2 is a side view which shows an essential part of a front device provided in the hydraulic excavator of FIG. 1.

[FIG. 3] FIG. 3 is a motion explanatory drawing of a connection pin that connects a first middle arm with a second middle arm provided in the front device.

[FIG. 4] FIG. 4 is a circuit diagram which shows a hydraulic drive unit of the front device.

[FIG. 5] FIG. 5 is an explanatory drawing which shows a working attitude of the front device.

[FIG. 6] FIG. 6 is an explanatory drawing which shows a working attitude of a front device provided in a hydraulic excavator related to a comparative example.

[FIG. 7] FIG. 7 is an explanatory drawing for an essential part which shows a folding starting state of the front device.

[FIG. 8] FIG. 8 is an explanatory drawing for an essential part which shows a folding completion state of the front device.

[FIG. 9] FIG. 9 is a side view which shows an essential part of a front device provided in a hydraulic ex-

cavator related to a second embodiment of the present invention.

[FIG. 10] FIG. 10 is an explanatory drawing which shows a folding starting state of the front device.

[FIG. 11] FIG. 11 is an explanatory drawing which shows a folding intermediate state of the front device.

[FIG. 12] FIG. 12 is an explanatory drawing which shows a folding completion state of the front device.

DESCRIPTION OF EMBODIMENTS

[0013] Embodiments of the present invention will be hereinafter explained referring to FIG. 1 to FIG. 12.

[0014] FIG. 1 is a side view which shows a hydraulic excavator 1 of the multi-boom type which is an example of the work machine related to a first embodiment of the present invention. As shown in FIG. 1, this hydraulic excavator 1 is generally configured of a self-propelling undercarriage 2, an upper structure 3, and a front device 4 described below, the upper structure 3 swingably mounted on the undercarriage 2 and configuring a vehicle body along with the undercarriage 2, the front device 4 being arranged in front of the upper structure 3 so as to be capable of elevated and depressed motions, and is used suitably to demolish a structure with a large height above the ground level such as an architectural structure.

[0015] The upper structure 3 is generally configured of a swing frame 5, a cab 6, a counterweight 7, an engine, and a housing cover 8, the swing frame 5 becoming a base, the cab 6 being disposed on the left side of the front part of the swing frame 5 and defining the operation room, the counterweight 7 being disposed on the rear end side of the swing frame 5, the engine being disposed in front of the counterweight 7 and not being illustrated, and the housing storing mounted devices such as a hydraulic pump.

[0016] The front device 4 is generally configured of a multi-boom, a middle arm 12, an arm 13, and a working tool 14, the multi-boom including a lower boom 9, two middle booms 10, and an upper boom 11, the middle arm 12 being rotatably connected to the tip side of the upper boom 11, the arm 13 being rotatably connected to the tip side of the middle arm 12, and the working tool 14 being rotatably connected to the tip side of the arm 13.

[0017] The base end side of the lower boom 9 is rotatably connected to the swing frame 5 at the center of the front part of the upper structure 3, and a boom cylinder 15 is attached between the lower boom 9 and the upper structure 3. Two middle booms 10 are pin-joined to the tip side of the lower boom 9, and the upper boom 11 is pin-joined to the tip side of the upper middle boom 10. Also, the multi-boom including these lower boom 9, two middle booms 10, and upper boom 11 rotates (is elevated and depressed) in the vertical direction by extension and contraction of the boom cylinder 15.

[0018] The middle arm 12 is bisected into a first middle arm 17 and a second middle arm 18, the first middle arm 17 being rotatably connected to the tip side of the upper

boom 11 through a pivot shaft 16, and the second middle arm 18 being rotatably connected to the rear end side of the arm 13 through a pivot shaft 19. The length of the first middle arm 17 is sufficiently short compared to the length of the second middle arm 18, and the length of the first middle arm 17 is set to approximately $L/5$ to $L/4$ where L is the total length of the middle arm 12. Although the detail will be described below, these first middle arm 17 and second middle arm 18 are connected to each other at two positions of a pivot pin 20 on the inner side and a connection pin 21 on the outer side to become an integrated body, and is made foldable around the pivot pin 20 by extracting the connection pin 21.

[0019] A middle arm cylinder 22 is attached between the first middle arm 17 and the upper boom 11, and the middle arm 12 is rotated around the pivot shaft 16 by extension and contraction of the middle arm cylinder 22. Also, a connection cylinder 23 is attached between the base end side of the second middle arm 18 and the upper boom 11, and, as described below, folding operation of the first middle arm 17 and the second middle arm 18 is executed in a state where this connection cylinder 23 is locked to the contracted position.

[0020] The arm 13 is configured of a lower arm 13a and an upper arm 13b, the lower arm 13a being rotatably connected to the second middle arm 18 through the pivot shaft 19, and the upper arm 13b being pin-joined to the tip side of the lower arm 13a, and the length of the lower arm 13a is set to be sufficiently short compared to the length of the upper arm 13b. Also, an arm cylinder 24 is attached between the second middle arm 18 and the lower arm 13a, and the arm 13 (the lower arm 13a and the upper arm 13b) rotates around the pivot shaft 19 by extension and contraction of the arm cylinder 24. Further, a working tool cylinder 25 is attached between the upper arm 13b and the working tool 14, and the working tool 14 rotates around a pivot shaft 26 by extension and contraction of the working tool cylinder 25. The working tool 14 is an attachment having a function suitable for the working content of the hydraulic excavator 1, and the working tool 14 such as a crusher and a breaker is attached to the tip side of the arm 13 in the case of demolishing work of a high-rise construction.

[0021] FIG. 2 is a side view which shows an essential part of the front device 4. As described above, the first middle arm 17 and the second middle arm 18 configuring the middle arm 12 are connected to each other at two positions of the pivot pin 20 on the inner side and the connection pin 21 on the outer side and are made to be an integrated body. Here, although the pivot pin 20 is a lock pin that is prevented from falling out, the connection pin 21 is configured of a hydraulic detachable pin that is extractable.

[0022] The bottom side of the middle arm cylinder 22 is attached to the vicinity of the center of the upper boom 11, and the rod side of the middle arm cylinder 22 is attached to the vicinity of the pivot pin 20 of the first middle arm 17. Also, the bottom side of the connection cylinder

23 is attached to the tip side of the upper boom 11, and the rod side of the connection cylinder 23 is attached to the base end side of the second middle arm 18, the base end side being close to the pivot pin 20. Further, the bottom side of the arm cylinder 24 is attached to the vicinity of the center of the second middle arm 18, and the rod side of the arm cylinder 24 is attached to the lower arm 13a. Also, in FIG. 2, with respect to the arm 13, only the lower arm 13a is illustrated, and illustration of the upper arm 13b is omitted.

[0023] FIG. 3 is a motion explanatory drawing of the connection pin 21, and FIG. 3(a) shows an engaged state and FIG. 3(b) shows an extracted state respectively. Here, the first middle arm 17 is formed as a box structural body including an upper surface, a lower surface, and both of left and right side surfaces, and, in a similar manner, the second middle arm 18 is also formed as a box structural body including an upper surface, a lower surface, and both of left and right side surfaces.

[0024] As shown in FIG. 3, on both of the left and right side surfaces of the first middle arm 17, an outer bracket 17A and an inner bracket 17B opposing each other at a constant interval are arranged respectively, and brackets 18A are disposed between these outer bracket 17A and inner bracket 17B, the brackets 18A forming the left and right side surfaces of the second middle arm 18. Pin insertion holes 17a are bored in the outer bracket 17A and the inner bracket 17B of the first middle arm 17, and pin insertion holes 18a are bored also in the brackets 18A of the second middle arm 18, the pin insertion holes 18a being positioned on an axis same to that of the pin insertion holes 17a. The connection pin 21 is formed into a circular column shape extending in the left-right direction, and is extractably inserted to the respective insertion holes 17a, 18a.

[0025] An insertion motion and an extraction motion are executed for a pair of the connection pins 21 to/from the pin insertion holes 17a, 18a in the left side surface and the pin insertion holes 17a, 18a in the right side surface by a detaching mechanism 37. This detaching mechanism 37 is configured of an actuation cylinder 38, a floating link 27, a left link 28, a right link 29, and the like. The actuation cylinder 38 is a hydraulic cylinder, the rear end part of the left link 28 is rotatably connected to the bottom side thereof, and the rear end part of the right link 29 is rotatably connected to the rod side thereof. The tip part of the left link 28 is rotatably connected to the connection pin 21 of the left side, and the tip part of the right link 29 is rotatably connected to the connection pin 21 of the right side. The floating link 27 is disposed to be movable between the left and right inner brackets 17B, and a shaft portion 28a of the left link 28 and a shaft portion 29a of the right link 29 are rotatably supported by this floating link 27.

[0026] Accordingly, when the actuation cylinder 38 is contracted, the right link 29 rotates around the fulcrum of the shaft portion 29a, and the left link 28 rotates reversely around the fulcrum of the shaft portion 28a. Thus,

when the actuation cylinder 38 is contracted, as shown in FIG. 3(a), the left and right connection pins 21 are inserted to the corresponding pin insertion holes 17a and pin insertion holes 18a respectively, and therefore the first middle arm 17 and the second middle arm 18 come into a state of being connected to each other at two positions of the pivot pin 20 and the connection pin 21.

[0027] On the other hand, when the actuation cylinder 38 is extended, as shown in FIG. 3(b), the connection pin 21 on the left side is extracted from the pin insertion hole 17a of the outer bracket 17A and the pin insertion hole 18a of the bracket 18A, the connection pin 21 on the right side is also extracted from the pin insertion hole 17a of the outer bracket 17A and the pin insertion hole 18a of the bracket 18A, and therefore the first middle arm 17 and the second middle arm 18 come into a state of being connected to each other only at one position of the pivot pin 20.

[0028] FIG. 4 is a circuit diagram which shows a hydraulic drive unit of the front device 4. This hydraulic drive unit is configured to include a tank 30, a main pump 31 of a variable displacement type, a pilot pump 32 and a sub-pump 33 of a fixed displacement type, a first directional control valve 34, a second directional control valve 41, a directional solenoid valve 40, a pilot valve 42, a stop valve 43, and the like in addition to the hydraulic cylinders such as the middle arm cylinder 22, the connection cylinder 23, the actuation cylinder 38 and the like described above (illustration of the boom cylinder 15, the arm cylinder 24, the working tool cylinder 25 is omitted).

[0029] The main pump 31, the pilot pump 32, and the sub-pump 33 are driven by an engine not illustrated. When the pilot valve 42 is operated by operation of a lever inside the cab 6, the first directional control valve 34 is switched from the center position to the left position or the right position according to the operation amount of the pilot valve 42. Thus, since pressure oil discharged from the main pump 31 is supplied to the middle arm cylinder 22 and the connection cylinder 23 through the first directional control valve 34, the middle arm 12 is rotated by extension and contraction of these middle arm cylinder 22 and connection cylinder 23. Here, the stop valve 43 is arranged in a pipe line connecting the connection cylinder 23 and the first directional control valve 34 to each other, and when a switch and the like not illustrated is operated and the stop valve 43 is closed, the connection cylinder 23 is locked to the contracted position irrespective of operation of the pilot valve 42.

[0030] Also, when the directional solenoid valve 40 is switched from the center position to the left position or the right position by operation of a switch and the like not illustrated, pilot pressure oil flowing from the directional solenoid valve 40 is applied to a pressure receiving portion of the second directional control valve 41, and the second directional control valve 41 is switched from the center position to the left position or the right position. Thus, pressure oil discharged from the sub-pump 33 is supplied to the actuation cylinder 38 through the second

directional control valve 41, and therefore attachment/detachment operation of the connection pin 21 is executed by extension and contraction of the actuation cylinder 38. Also, pins connecting the lower boom 9, the middle booms 10, and the upper boom 11 of the multi-boom are hydraulic detachable pins similar to the connection pin 21, the reference sign 44 in FIG. 4 expresses an actuation cylinder of a pin connecting the lower boom 9 and the lower middle boom 10 to each other, the reference sign 45 expresses an actuation cylinder of a pin connecting the upper and lower middle booms 10 to each other, and the reference sign 46 expresses an actuation cylinder of a pin connecting the upper boom 11 and the upper middle boom 10 to each other respectively.

[0031] The hydraulic excavator 1 related to the present embodiment has such configuration as described above. When demolishing work of an architectural structure for example is to be executed using this hydraulic excavator 1, the architectural structure is demolished using the working tool 14 while the undercarriage 2 is made to travel and while the upper structure 3 is made to swing.

[0032] FIG. 5 is an explanatory drawing which shows a working attitude of the front device 4 provided in the hydraulic excavator 1. According to the present embodiment, the middle arm 12 that is a constituent member of the front device 4 is configured of the first middle arm 17 and the second middle arm 18, and uses the middle arm 12 whose total length is long. Therefore, a working range S defined by a locus of the tip side of the arm 13 around the pivot shaft 16 on the rear end side of the middle arm 12 and a locus of the tip side of the arm 13 around the pivot shaft 19 on the tip side of the middle arm 12 can be widened. Accordingly, although the working tool 14 is omitted in FIG. 5, even when the undercarriage 2 is not made to travel purposely, the working tool attached to the tip side of the arm 13 becomes operable within a wide range, and the working efficiency in demolishing an architectural structure using the working tool 14 can be improved.

[0033] FIG. 6 is an explanatory drawing which shows a working attitude of a front device including a middle arm with a short length as a comparative example of the hydraulic excavator 1 related to the present embodiment. As shown in FIG. 6, in the case of a hydraulic excavator 100 related to the comparative example, the length of a middle arm 102 becomes very short compared to the total length of an arm 101. Therefore, a working range S1 defined by a locus of the tip side of the arm 101 around a pivot shaft 103 on the rear end side of the middle arm 102 and a locus of the tip side of the arm 101 around a pivot shaft 104 on the tip side of the middle arm 102 becomes narrow, and the working region of a working tool attached to the tip side of the arm 101 is largely restricted.

[0034] Next, explanation will be made on a case of transporting the hydraulic excavator 1 related to the present embodiment to a working site and the like. When the hydraulic excavator 1 is to be transported, for exam-

ple, the front device 4 is folded into a minimum attitude, the middle boom 10 and onward are thereafter detached from the upper structure 3, the front device 4 is disintegrated, the front device 4 is separated from the vehicle body, and they are mounted on transportation vehicles such as trailers and are transported to the working site individually.

[0035] Here, when the front device 4 is to be folded into a minimum attitude, as shown in FIG. 7, first, by making both of the middle arm cylinder 22 and the arm cylinder 24 contract, three members of the upper boom 11, the middle arm 12 (the first middle arm 17 and the second middle arm 18), and the arm 13 are folded into a C-shape. Next, the upper arm 13b of the tip side of the arm 13 including the working tool cylinder 25 is detached from the lower arm 13a. Next, the detaching mechanism 37 is operated to move the connection pin 21 to the extracted position, thereby the connection state of the first middle arm 17 and the second middle arm 18 by the connection pin 21 is released, and thereafter the middle arm cylinder 22 and the arm cylinder 24 are extended while the connection cylinder 23 is locked to the contracted position.

[0036] Also, when the middle arm cylinder 22 extends, the first middle arm 17 rotates clockwise of the drawing around the pivot shaft 16, and the second middle arm 18 rotates counterclockwise of the drawing around the pivot pin 20 because the upper boom 11 and the second middle arm 18 are connected to each other through the connection cylinder 23 that is under the lock state. Further, by extension of the arm cylinder 24, the second middle arm 18 and the lower arm 13a continue to each other linearly, and therefore the front device 4 comes to have a low profile attitude where the second middle arm 18 and the lower arm 13a are stored below the upper boom 11 (the multi-boom) through the first middle arm 17 as shown in FIG. 8. Therefore, even when the upper boom 11, the middle arm 12, and the lower arm 13a are not disintegrated into each component purposely, only by extracting the connection pin 21 having connected the first middle arm 17 and the second middle arm 18 to each other, the upper boom 11, the middle arm 12, and the lower arm 13a can be folded into a minimum attitude of a degree of falling within the height limitation in transportation, and working time and working man-hour required for transportation preparation can be reduced significantly.

[0037] As explained above, according to the hydraulic excavator 1 related to the first embodiment, the middle arm 12 that is a constituent member of the front device 4 is bisected into the first middle arm 17 and the second middle arm 18, the first middle arm 17 being rotatably connected to the tip side of the upper boom 11, and one end part of the middle arm cylinder 22 being attached to the first middle arm 17, and the second middle arm 18 being rotatably connected to the rear end side of the arm 13, and one end part of the arm cylinder 24 being attached to the second middle arm 18. These first middle arm 17 and second middle arm 18 are connected to each other at two positions of the inner pivot pin 20 and the outer

connection pin 21, the pivot pin 20 being prevented from falling out, the connection pin 21 being extractable, and are foldable around the pivot pin 20 when the connection pin 21 is extracted. Therefore, the first middle arm 17 and the second middle arm 18 can be integrated to widen the working range when the front device 4 works. Also, since the first middle arm 17 and the second middle arm 18 come to be rotatable around the pivot pin 20 by extracting the connection pin 21, the transportation height of the front device 4 can be made to have a low profile.

[0038] Further, according to the hydraulic excavator 1 related to the first embodiment, the connection cylinder 23 is attached between the upper boom 11 and the second middle arm 18, it is configured that the connection cylinder 23 is locked to the contracted position in folding motion of the front device 4, and therefore the front device 4 can be folded into a minimum attitude only by extending the middle arm cylinder 22 and the arm cylinder 24 after extracting the connection pin 21.

[0039] FIG. 9 is a side view which shows an essential part of a front device provided in a hydraulic excavator related to the second embodiment of the present invention.

[0040] The point the second embodiment shown in FIG. 9 differs from the first embodiment is that a connection arm 35 is used instead of the connection cylinder 23, and configurations other than that are basically the same. This connection arm 35 is rotatably supported by a bracket 11a arranged on the tip side of the upper boom 11, and the tip part of the connection arm 35 is engageable/disengageable with a holding portion 11b arranged in the vicinity of the center of the upper boom 11. Also, on the base end side of the second middle arm 18, a locking portion 36 is arranged, the locking portion 36 capable of latching the tip part of the connection arm 35.

[0041] When the front device works, as shown in FIG. 9, the connection arm 35 is held by the upper boom 11. Also, when the front device is to be folded into a minimum attitude, first, by contracting both of the middle arm cylinder 22 and the arm cylinder 24, three members of the upper boom 11, the middle arm 12 (the first middle arm 17 and the second middle arm 18), and the arm 13 are folded into a C-shape, and the tip side of the arm 13 including the working tool cylinder 25 is detached from the base end side. Next, as shown in FIG. 10, after the tip part of the connection arm 35 is detached from the holding portion 11b to be latched to the locking portion 36 of the second middle arm 18, the detaching mechanism 37 is operated to move the connection pin 21 to the extracted position, and thereby the connection state of the first middle arm 17 and the second middle arm 18 by the connection pin 21 is released.

[0042] When the middle arm cylinder 22 is extended in this state, as shown in FIG. 11, the first middle arm 17 rotates clockwise in the drawing around the pivot shaft 16, and the second middle arm 18 rotates counterclockwise in the drawing around the pivot pin 20 since the upper boom 11 and the second middle arm 18 are con-

nected to each other through the connection arm 35. Also, when the middle arm cylinder 22 is extended and the arm cylinder 24 is extended simultaneously, as shown in FIG. 12, the second middle arm 18 and the lower arm 13a are stored linearly below the upper boom 11 (the multi-boom) through the first middle arm 17, and the front device comes to a state of being folded into a minimum attitude.

[0043] In the hydraulic excavator 1 also related to the second embodiment configured thus, when the front device works, by integrating the first middle arm 17 and the second middle arm 18 to each other to configure the long middle arm 12, the working range of the front device can be widened. Also, since the first middle arm 17 and the second middle arm 18 become rotatable around the pivot pin 20 by latching the connection arm 35 to the locking portion 36 of the second middle arm 18 by extracting the connection pin 21, the transportation height of the front device can be made to have a low profile.

[0044] Further, the respective embodiments described above are exemplifications for explanation of the present invention, and they do not intend that the scope of the present invention is limited to those embodiments only. A person with an ordinary skill in the art can effect the present invention in other various aspects without departing from the gist of the present invention.

[0045] For example, instead of using the connection cylinder 23 and the connection arm 35, it is also possible to arrange an unillustrated wheel on the tip side of the lower arm 13a to allow the wheel to roll to the vehicle body side by a boom lowering motion, and thereby to configure the first middle arm 17 and the second middle arm 18 to be folded.

[0046] Further, although explanation was made for a case of using the connection pin 21 formed of the hydraulic detachable pin including the actuation cylinder 38, the link mechanism, and the like in the respective embodiments described above, it is also possible to use the connection pin 21 of a manual type inserted/extracted by a worker.

REFERENCE SIGNS LIST

[0047]

- | | |
|-----|------------------------------------|
| 1 | hydraulic excavator (work machine) |
| 2 | undercarriage |
| 3 | upper structure |
| 4 | front device |
| 6 | cab |
| 9 | lower boom |
| 10 | middle boom |
| 11 | upper boom |
| 11a | bracket |
| 11b | holding portion |
| 12 | middle arm |
| 13 | arm |
| 14 | working tool |

- | | |
|-------|-----------------------|
| 15 | boom cylinder |
| 16 | pivot shaft |
| 17 | first middle arm |
| 18 | second middle arm |
| 5 19 | pivot shaft |
| 20 | pivot pin |
| 21 | connection pin |
| 22 | middle arm cylinder |
| 23 | connection cylinder |
| 10 24 | arm cylinder |
| 25 | working tool cylinder |
| 26 | pivot shaft |
| 35 | connection arm |
| 36 | locking portion |
| 15 37 | detachable mechanism |
| 38 | actuation cylinder |

Claims

1. A work machine, comprising:

a self-propelling vehicle body;
 a boom attached to the vehicle body so as to be capable of elevated and depressed motions;
 a middle arm rotatably connected to a tip side of the boom;
 an arm rotatably connected to the tip side of the middle arm;
 a working tool attached to the tip side of the arm;
 a boom cylinder attached between the vehicle body and the boom;
 a middle arm cylinder attached between the boom and the middle arm; and
 an arm cylinder attached between the middle arm and the arm,
 wherein the middle arm is bisected into a first middle arm and a second middle arm, the first middle arm being rotatably connected to the tip side of the boom, and one end part of the middle arm cylinder being attached to the first middle arm, the second middle arm being rotatably connected to a rear end side of the arm, and one end part of the arm cylinder being attached to the second middle arm,
 the first middle arm and the second middle arm are connected to each other at two positions by an inner pivot pin and an outer connection pin, the pivot pin being prevented from falling out, the connection pin being extractable, and
 when the connection pin is extracted from the first middle arm and the second middle arm, the second middle arm rotates around the pivot pin to be folded with respect to the first middle arm.

2. The work machine according to claim 1,

wherein a connection cylinder is attached be-

tween the boom and the second middle arm, and the connection cylinder is locked to a contracted state when the second middle arm is in a folding motion with respect to the first middle arm.

3. The work machine according to claim 1, further comprising a connection arm capable of connecting the boom and the second middle arm to each other, wherein the connection arm is connected between the boom and the second middle arm when the second middle is in a folding motion with respect to the first middle arm.
4. The work machine according to claim 1, wherein the connection pin is configured to connect or disconnect the first middle arm and the second middle arm to/from each other according to an extension state or a contracted state of a working cylinder.

Amended claims under Art. 19.1 PCT

1. (as amended) A work machine, comprising:

a self-propelling vehicle body;
 a boom attached to the vehicle body so as to be capable of elevated and depressed motions;
 a middle arm rotatably connected to a tip side of the boom;
 an arm rotatably connected to the tip side of the middle arm;
 a working tool attached to the tip side of the arm;
 a boom cylinder attached between the vehicle body and the boom;
 a middle arm cylinder attached between the boom and the middle arm; and
 an arm cylinder attached between the middle arm and the arm,
 wherein the middle arm is bisected into a first middle arm and a second middle arm, the first middle arm being rotatably connected to the tip side of the boom, and one end part of the middle arm cylinder being attached to the first middle arm, the second middle arm being rotatably connected to a rear end side of the arm, and one end part of the arm cylinder being attached to the second middle arm,
 the first middle arm and the second middle arm are connected to each other at two positions by an inner pivot pin and an outer connection pin, the pivot pin being prevented from falling out, the connection pin being extractable, and when the connection pin is extracted from the first middle arm and the second middle arm, and the second middle arm is rotated around the pivot pin with respect to the first middle arm, the second middle arm and the arm are stored below the boom through the first middle arm.

2. The work machine according to claim 1,

wherein a connection cylinder is attached between the boom and the second middle arm, and the connection cylinder is locked to a contracted state when the second middle arm is in a folding motion with respect to the first middle arm.

3. The work machine according to claim 1, further comprising a connection arm capable of connecting the boom and the second middle arm to each other, wherein the connection arm is connected between the boom and the second middle arm when the second middle is in a folding motion with respect to the first middle arm.
4. The work machine according to claim 1, wherein the connection pin is configured to connect or disconnect the first middle arm and the second middle arm to/from each other according to an extension state or a contracted state of a working cylinder.

Statement under Article 19 (1)

The configuration of Claim 1 was limited.

Description of "when the second middle arm is rotated around the pivot pin with respect to the first middle arm, the second middle arm and the arm are stored below the boom through the first middle arm" is on the basis of the content described in the paragraphs [0036] and [0042] of the description and FIG. 8 and FIG. 12 at the time of the application.

FIG. 1

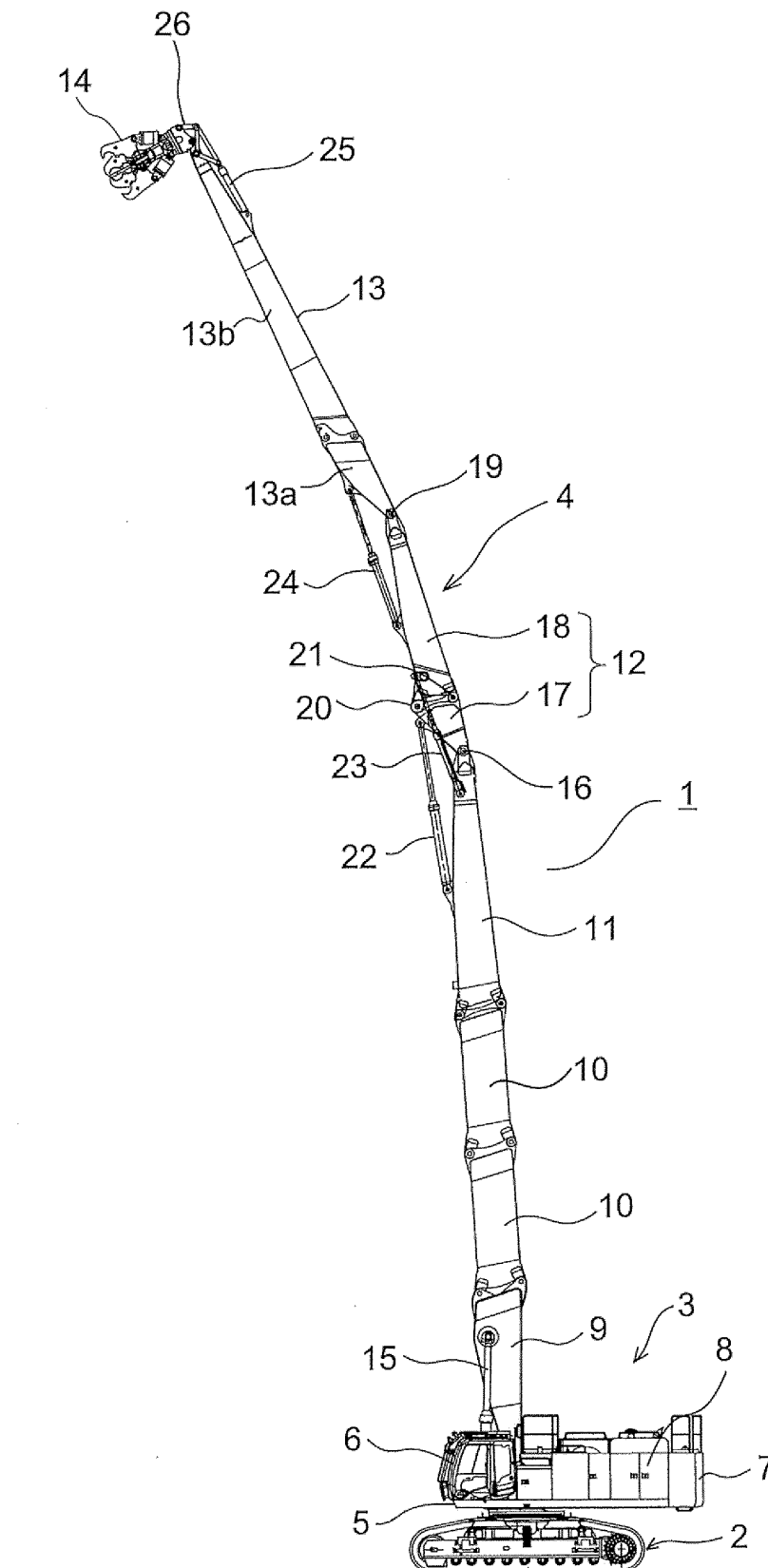


FIG. 2

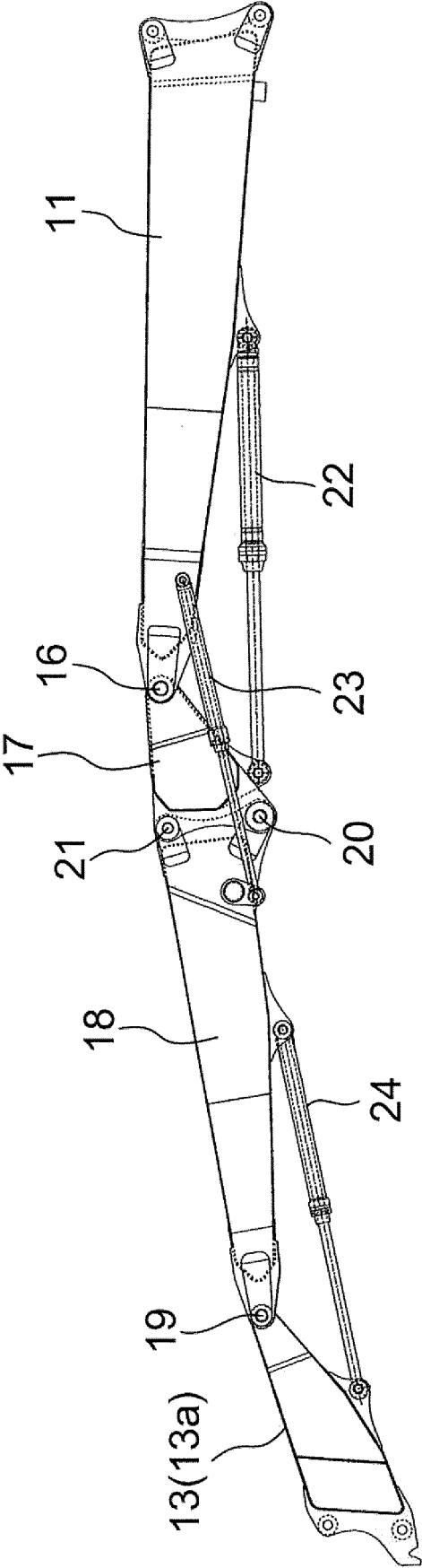


FIG. 3

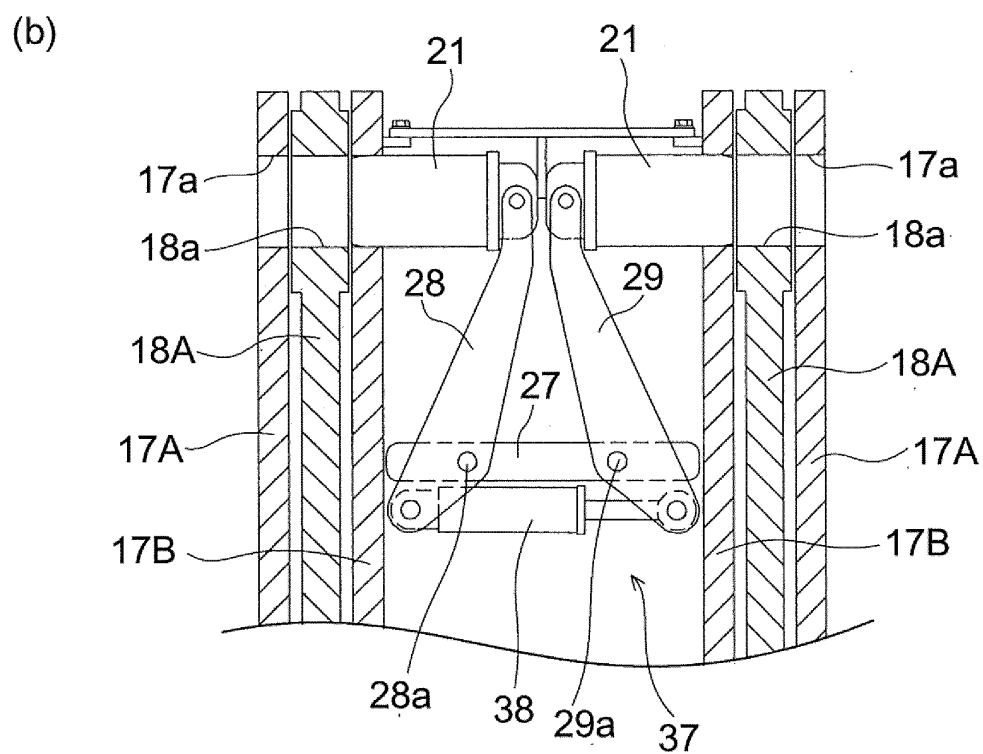
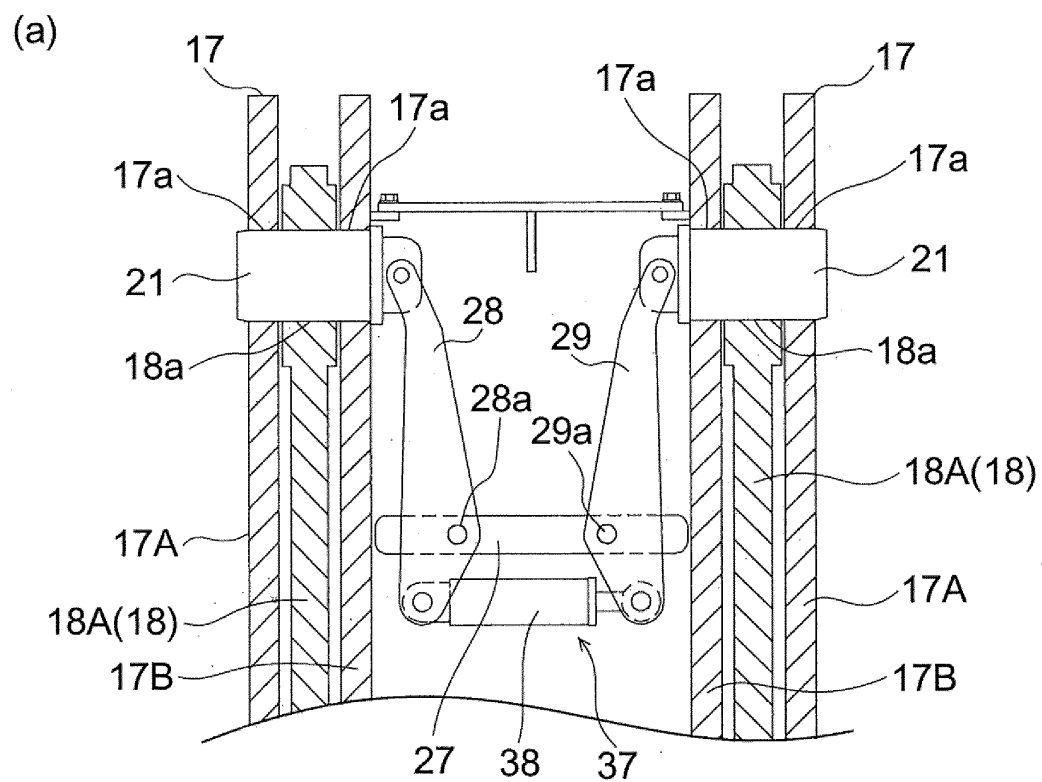


FIG. 4

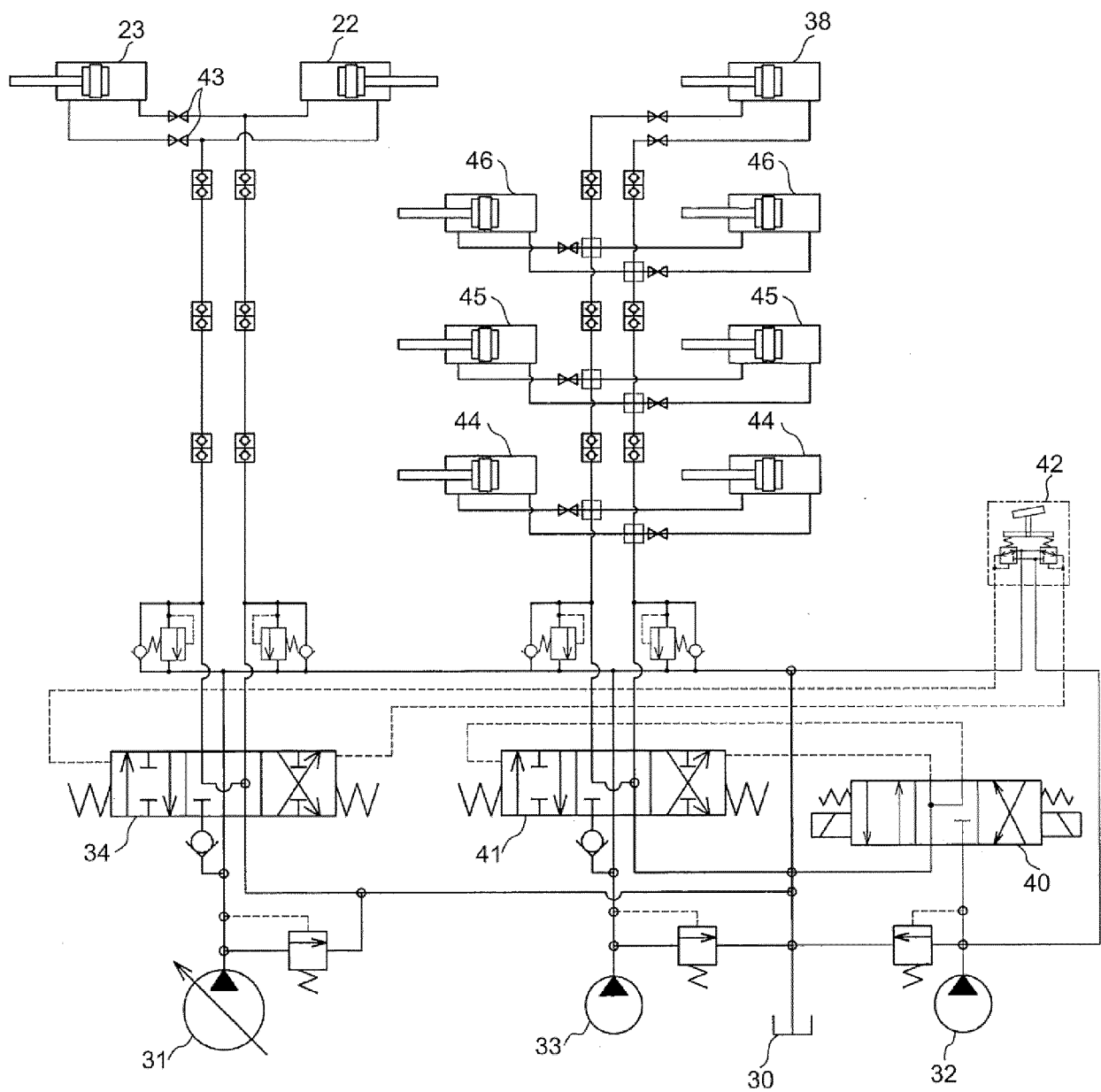


FIG. 5

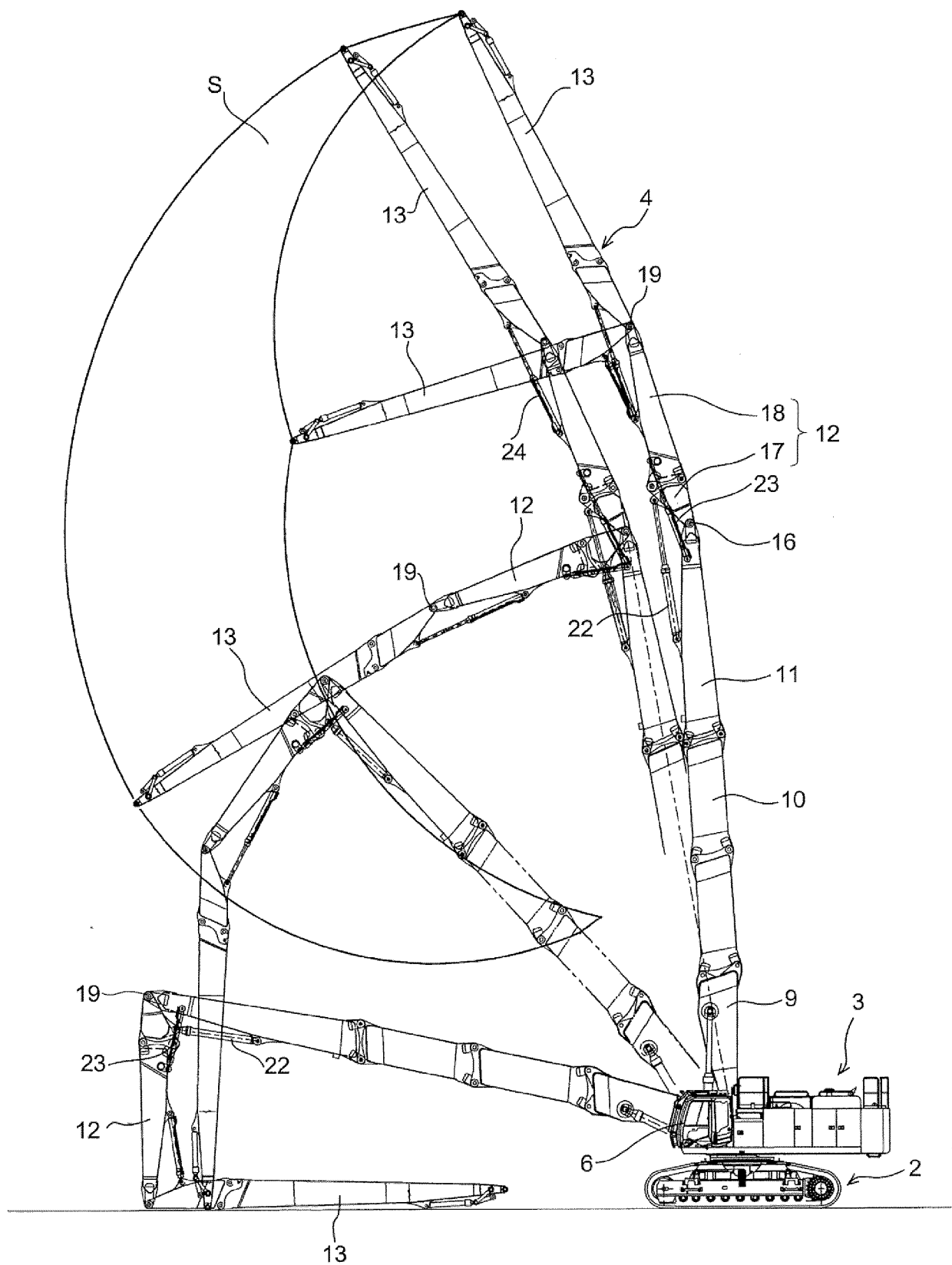


FIG. 6

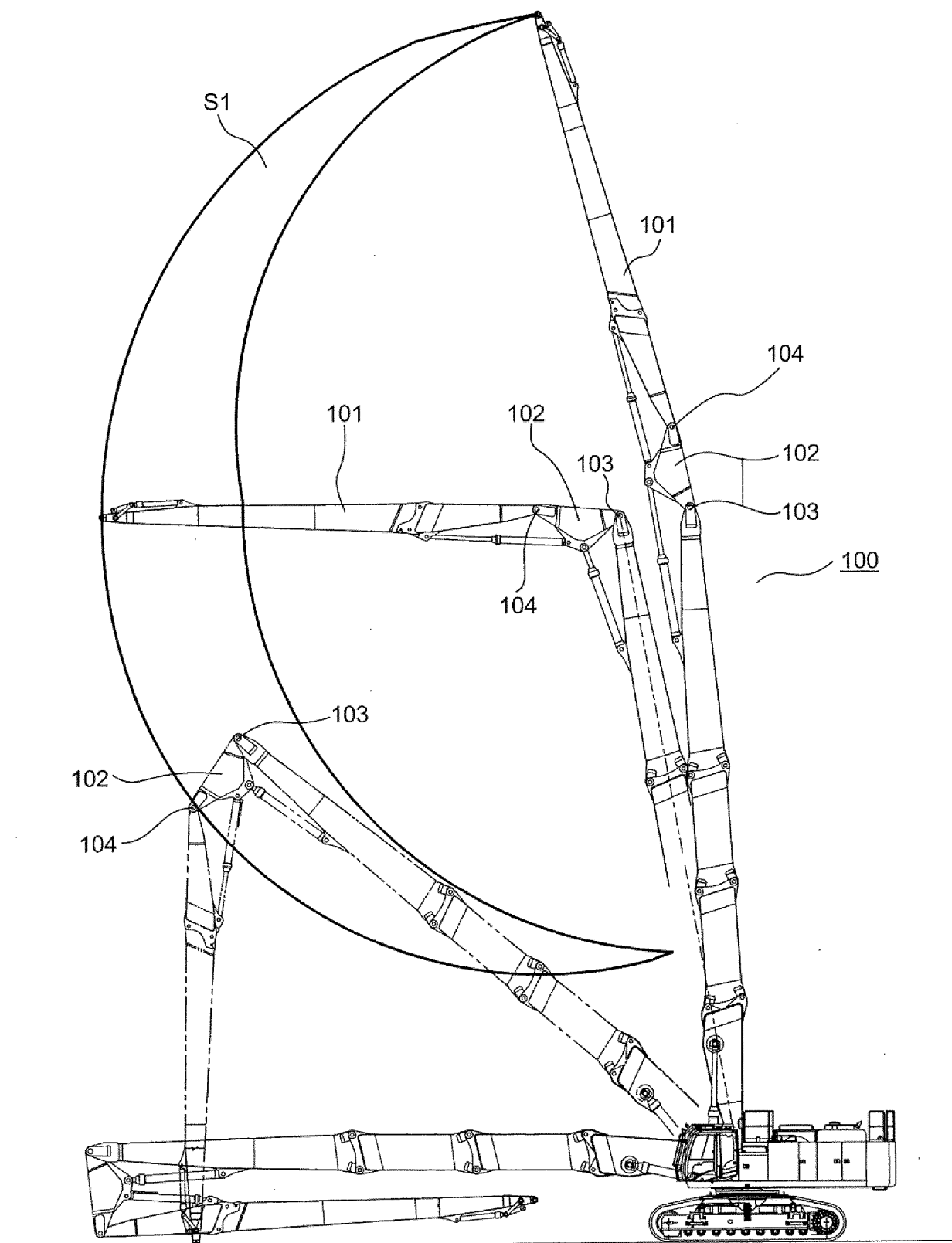


FIG. 7

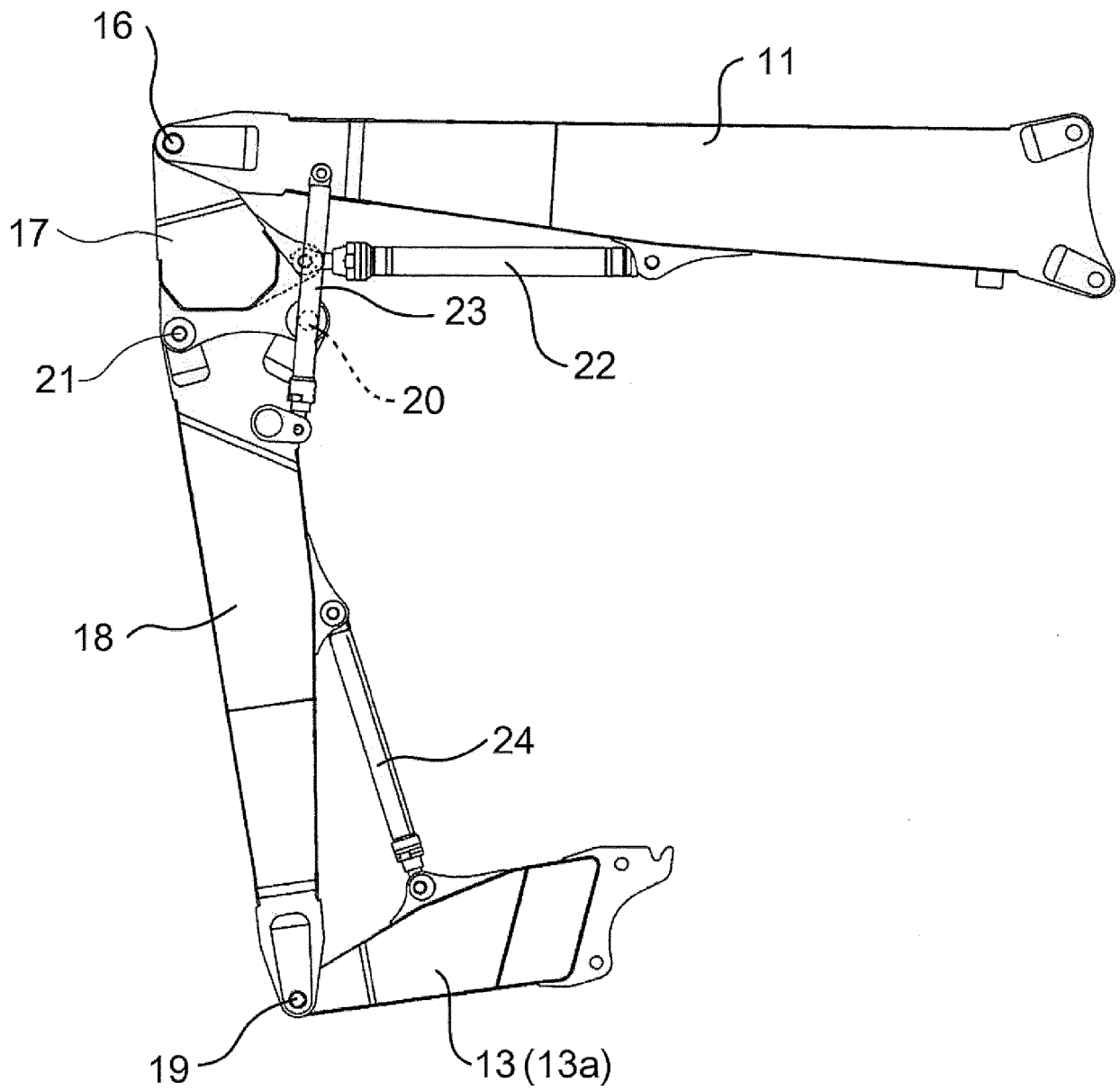


FIG. 8

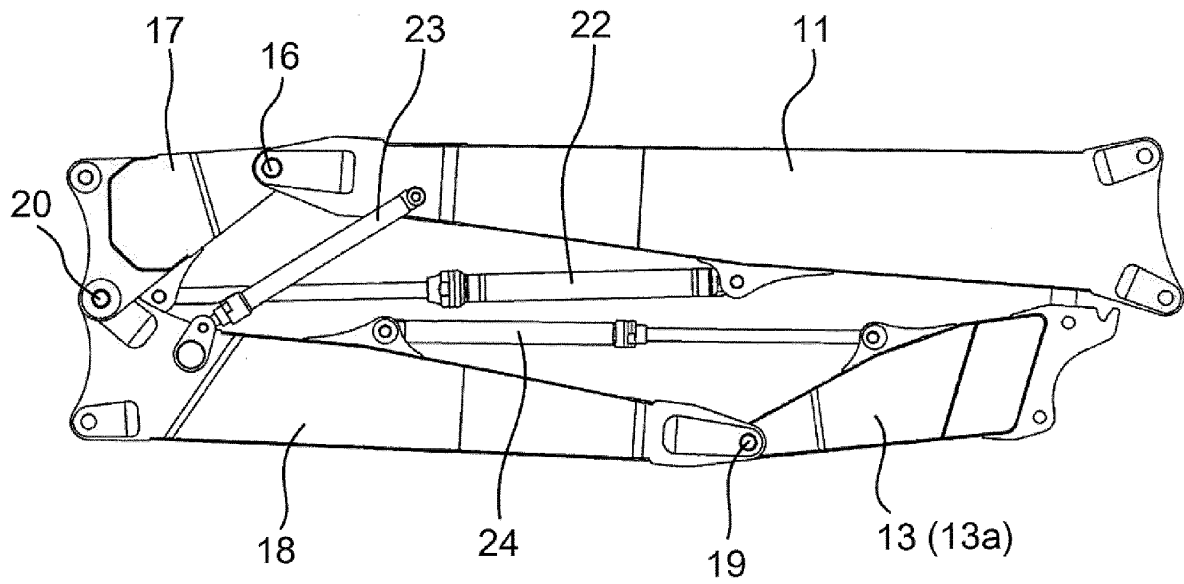


FIG. 9

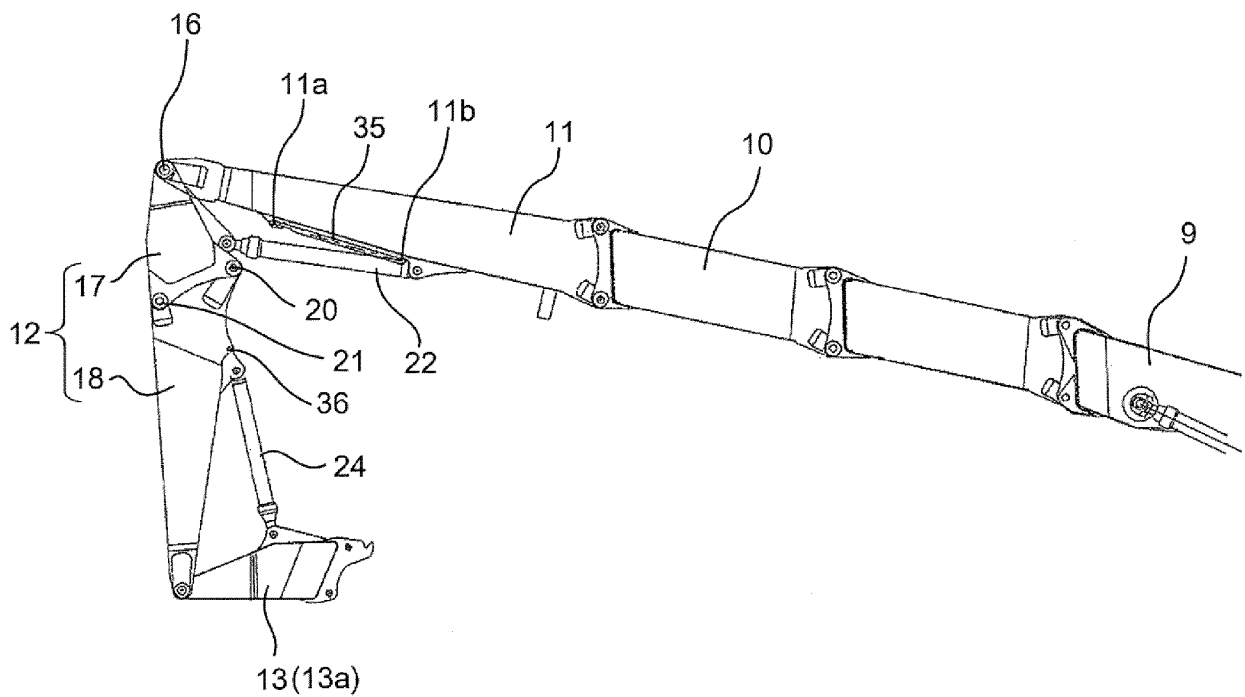


FIG. 10

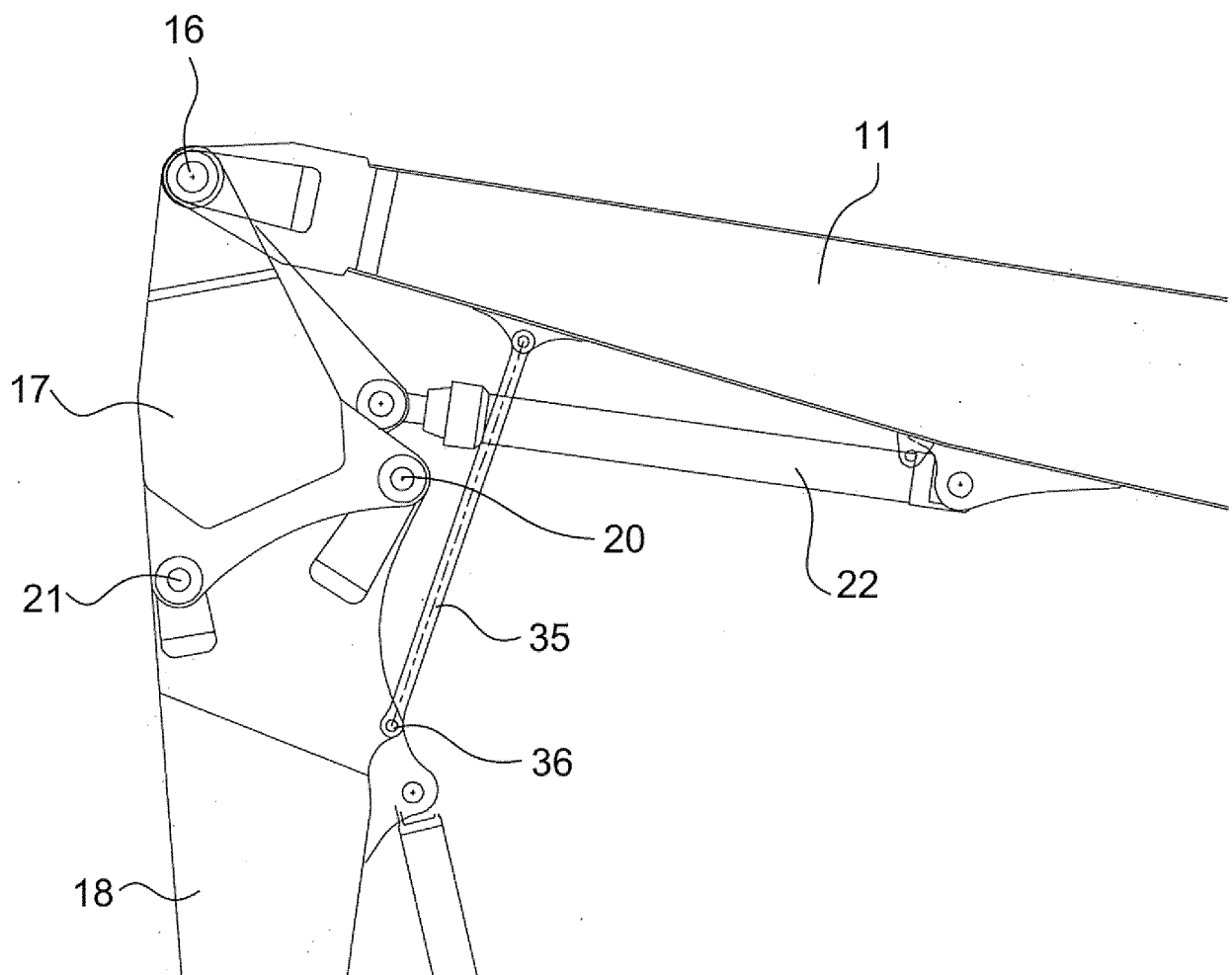


FIG. 11

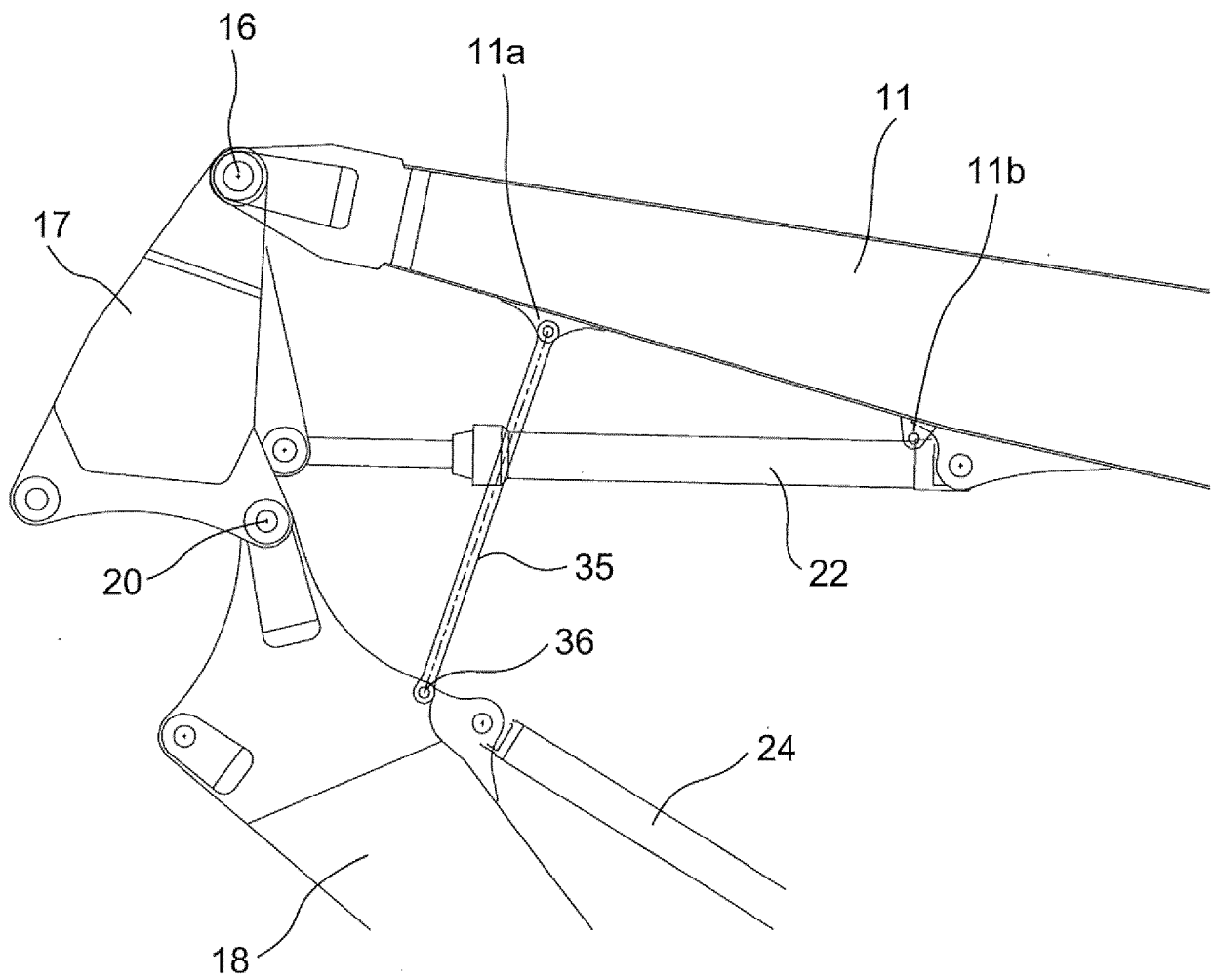
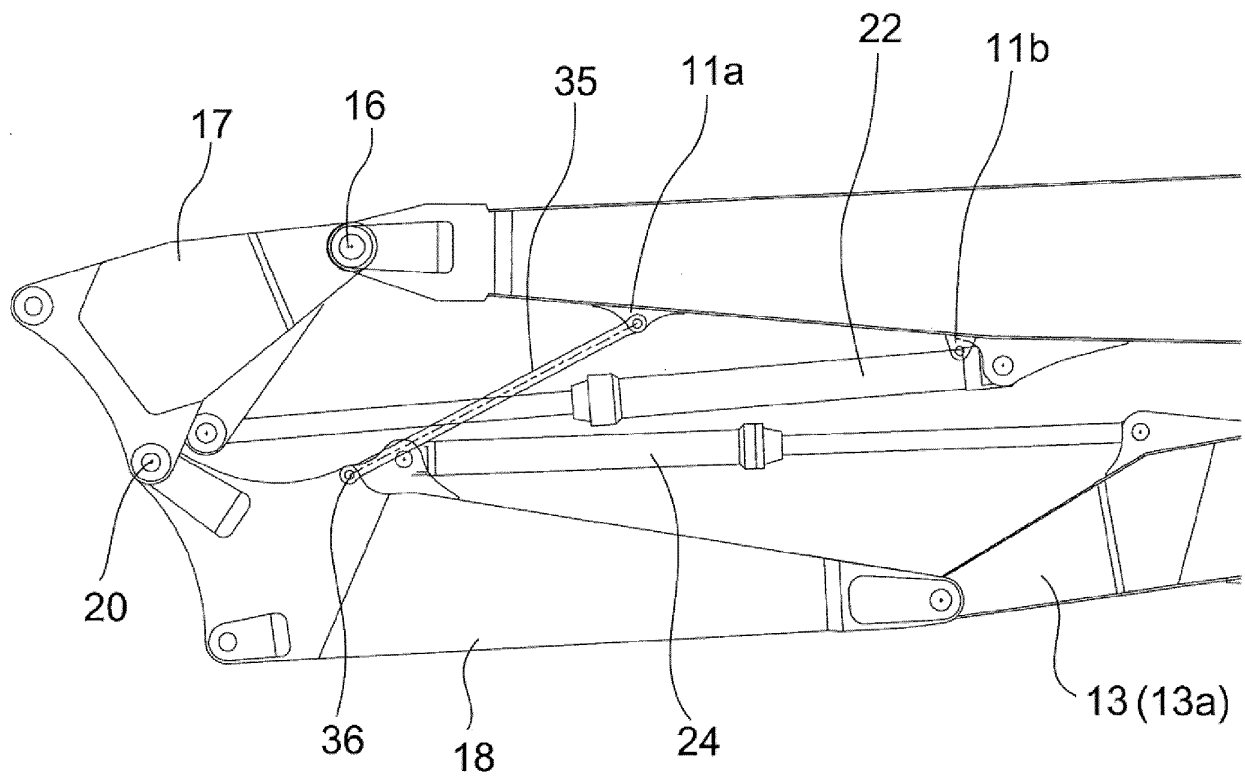


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/020100

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. E04G23/08 (2006.01) i, 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)

Int. Cl. E04G23/08, E02F3/38, B66C23/42

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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.
X A	JP 2014-101665 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 05 June 2014, paragraphs [0020]-[0039], fig. 1-9 (Family: none)	1, 4 2-3
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 44440/1992 (Laid-open No. 96154/1993) (YUTANI HEAVY INDUSTRIES, LTD.) 27 December 1993, entire text, all drawings (Family: none)	1-4
A	JP 2006-274725 A (SHIN CATERPILLAR MITSUBISHI LTD.) 12 October 2006, entire text, all drawings (Family: none)	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search
02.08.2019Date of mailing of the international search report
13.08.2019Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

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Patent documents cited in the description

- JP 2011256626 A [0006]