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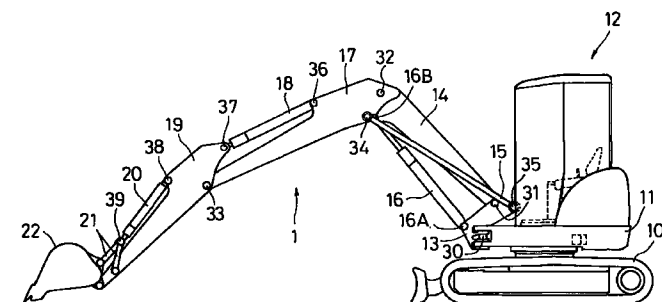
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(54) **Swing type excavator**

(57) In a swing type excavator a horizontal pin 31 as the coupling point between boom 14 and the swing post 13 is positioned rearwardly of a swing pin 30 as the swing center of the swing post 13 away from the front attachment. With this arrangement, the so-called ultra-small or undercarriage-width turn is realized without reducing both the side ditch distance in a side ditch digging condition and the maximum digging depth in a deep digging posture. Also, a swing post 13 is attached to an upper structure 11, which is able to turn within a width of an undercarriage 10, at a position forwardly and laterally of a cab 12. A front attachment 1, including a bucket 22, an arm 19, an upper boom 17, a lower boom 14 and a cross link 15, is mounted to the swing post 13.

The cross link 15 intersects a line connecting a coupling point between the upper boom 17 and the lower boom 14 and a coupling point between the lower boom 14 and the swing post 13, and changes an opening angle between the upper boom 17 and the lower boom 14 depending on a vertical tilt angle of the lower boom 14. With this arrangement, the upper structure including the front attachment can be turned within the undercarriage width by a simple construction with no need of using a complex link mechanism, and interference between the front attachment and the cab can be easily avoided when the front attachment is swung.

FIG.1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a swing type excavator in which a front attachment is swingable in the horizontal direction.

[0002] It is generally essential for small-sized hydraulic excavators to have a function capable of digging a side ditch in a near position transversely of the excavator without changing the body direction. This function is achieved by the swing type excavator.

[0003] As disclosed in JP-U-4-46149 and JP-U-5-47798, for example, the swing type excavator is of a structure that a swing post being able to swing horizontally is disposed in a front central portion of an upper structure forwardly of a cab, and a front attachment is mounted to the swing post. A side ditch digging can be performed by turning the upper structure and swinging the swing post so that the whole of the front attachment is swung in the horizontal direction. It is usual that a boom of the swing type excavator comprises a mono-boom bent at a certain angle for the purpose of deep digging.

[0004] Further, in conventional swing type excavator, as disclosed in JP-U-547798, a horizontal pin (boom foot pin) as a coupling point between a boom and a swing post is positioned forwardly of a swing pin as the swing center of the swing post toward a front attachment (hereinafter referred to as first prior art).

[0005] Meanwhile, to enable digging work to be performed in a narrow space, there has recently been developed an excavator which can realize the so-called undercarriage-width turn that not only an upper structure is turned generally within the width of an undercarriage, but also a front attachment, including a bucket, an arm and a boom, can be turned together generally within the undercarriage width while assuming a posture where the front attachment is folded above the upper structure (hereinafter referred to as a turning posture). Such an excavator is called an ultra-small turn hydraulic shovel or excavator. Since the ultra-small turn hydraulic excavator can take any directions within a circle of which diameter is given by the undercarriage width, it can perform desired work in any narrow place so long as the place has a width enough to allow an excavator body to pass there. For example, when construction work is executed in one lane of a two-lane road, the work can be performed while traffic is blocked not in both lanes, but in only one lane, which results in a minimum extent of traffic restriction.

[0006] Meanwhile, there is an offset type excavator as an excavator other than the swing type which has a function capable of digging a side ditch in a near position transversely of the excavator without changing the body direction.

[0007] As disclosed in JP-A-2-120427 and JP-A-2-213525, for example, the offset type excavator is of a

structure that a boom is divided into a lower boom and an upper boom, the upper boom being horizontally tiltable with respect to the lower boom, and a parallel link mechanism and a cylinder for driving the parallel link mechanism are disposed between the lower boom and the upper boom. Upon operation of the cylinder, an arm is translated with respect to the lower boom through an action of the parallel link mechanism. When digging a side ditch, therefore, the ditch can be dug in a desired position transversely of the excavator body within the undercarriage width with no need of turning the upper structure.

[0008] As the ultra small turn hydraulic excavator, there has hitherto been practiced offset type one (hereinafter referred to as second prior art). The reason is as follows. A boom usually has the form bent at a certain angle. To realize an ultra-small turn of the excavator having such a boom, one end of the boom is required to be supported to a position near the longitudinal center of an upper structure. However, if the excavator employs the swing type in combination with the construction that one end of the boom is supported to a position near the longitudinal center of the upper structure, the boom would interfere with a cab and a front attachment could not be swung to the same side as the cab, when the front attachment is horizontally swung with respect to the upper structure in an attempt at work of side ditch digging. Accordingly, the offset type excavator in which the arm is horizontally tiltable with respect to the boom must have been practiced to prevent an interference between the front attachment and the cab.

[0009] Another ultra-small turn hydraulic excavator which has also been practiced employs, based on the above offset type, a boom provided between an upper boom and a lower boom with an additional mechanism which enables the upper boom to be also vertically tiltable with respect to the lower boom, an opening angle between the two booms being changed by action of a cross link (hereinafter referred to as third prior art).

[0010] JP-U-2-84857 discloses a swing type excavator in which a boom comprises a lower boom vertically tiltable with respect to a swing post, and an upper boom vertically tiltable with respect to the lower boom (hereinafter referred to as fourth prior art). In this prior art, an opening angle between the two booms is changed by action of a cross link depending on a tilt angle of the lower boom so that when the lower boom is maximally tilted up (i.e., erected), the upper boom is straightly extended in the direction of extension of the lower boom, and when the lower boom is maximally tilted down (i.e., flattened), the upper boom is bent at a proper angle with respect to the lower boom. A swing post is disposed in a front central portion of an upper structure.

SUMMARY OF THE INVENTION

[0011] However, the prior art excavators have problems as follows.

[0012] In the case where the coupling point between the boom and the swing post is positioned forwardly of the swing center of the swing post toward the front attachment like the above-described first prior art, the position of the swing post on the upper structure must be moved rearwardly with respect to the front attachment so that the whole of the front attachment comes closer to the turn center of the upper structure, for achieving a reduction in the minimum turn radius. This results in the following problems.

(1) If the swing post is positioned closer to the turn center of the upper structure to reduce the minimum swing radius in the turning posture, the distance between the swing center of the front attachment and the turn center of the upper structure is shortened and, therefore, the front attachment is entirely moved toward the turn center of the upper structure when a side ditch is dug by turning the upper structure and swinging the whole of the front attachment in the opposite direction. Accordingly, the side ditch distance from an outer lateral surface of the undercarriage to an outer wall surface of the side ditch is reduced and the side ditch cannot be dug in a position transversely spaced from the longitudinal center of the excavator body by a distance comparable to that conventionally achieved.

(2) If the swing post is positioned closer to the turn center of the upper structure, a maximum tilt-down angle of the boom is required to be smaller than conventionally to avoid an interference between a blade provided to project forwardly from the excavator body and the boom or the boom cylinder. This reduces the maximum digging depth.

[0013] Further, in the offset type excavator as the second prior art, because the complex parallel link mechanism and the cylinder for driving it are required to be provided on the front attachment, the weight of the front attachment is increased, which is disadvantageous in the following points.

(1) The front attachment is so very heavy that the center of gravity is deviated toward its distal end and the excavator has poor stability depending on a posture of the front attachment. (2) Corresponding to the increased weight of the front attachment, it is also required to use a heavier counterweight. Therefore, the weight of the whole excavator becomes comparable to that of one which has a digging capability in a level one class higher than excavators being of not offset type but standard type. This pushes up a transportation cost. Furthermore, the size of the upper structure is increased, which is an obstacle in realizing an ultra-small turn. (3) Since the weight of the excavator body is increased, an engine output must be enlarged.

Hence a manufacture cost and a running cost are pushed up.

In addition, the offset type excavator has problems below because the arm and the bucket are offset parallel to the boom.

(4) A vertical pin is employed to couple the lower boom and the upper boom to each other, and it may be curved or broken when extremely large impact forces or vibrations are generated in the digging direction while crushing work is performed by using a breaker or the like as the front attachment.

(5) When digging a side ditch deeply, there is a possibility that a lower portion of the parallel link mechanism may interfere with the ground surface. Accordingly, the offset type excavator cannot achieve a digging depth comparable to that obtainable with standard type excavators.

(6) Because of using the complex parallel link mechanism, the manufacture cost is increased and maintenance work is more frequently required.

(7) When the arm and the bucket are offset to the side opposite to the cab, the field of view is obstructed by the boom, giving an operator difficulty in viewing the digging position from the cab.

(8) When the arm and the bucket are offset to the same side as the cab, there is a possibility that the bucket positioned in front of the cab may badly interfere with the cab. To avoid such a possibility, means for preventing the interference must be provided. However, an interference preventing device required for that purpose is complicated in its entire structure, including sensor means for detecting tilt angles of the lower boom and the arm making up the front attachment and an offset amount, as well as arithmetic means. This results in a higher manufacture cost.

[0014] The third prior art accompanies similar problems to those described above because of employing the same offset type as in the second prior art.

[0015] Meanwhile, in the swing type excavator, the foot end of the boom cannot be supported to a position near the longitudinal center of the upper structure, and hence the excavator cannot be constructed in such a manner as enabling the whole of the front attachment to turn within the undercarriage width, as described before. Stated otherwise, in the swing type excavator, the foot end of the boom is supported by the swing post disposed substantially centrally in front of the cab, and a mono-boom vertically bent at a certain angle is employed as the boom. Therefore, if the bent angle of the boom is set so as to enable deep digging when the boom is maximally tilted down, a part of the front attachment would project out of the undercarriage width upon the upper structure being turned even in a posture where the boom is maximally tilted up. Additionally, since the swing post is disposed substantially centrally in front of the cab, the cab has to be shifted rearwardly

on the narrow upper structure in order that the boom has a large tilt angle when it is maximally tilted up. This implies a difficulty in designing layout of the cab.

[0016] In the above-described fourth prior art, since the opening angle between the lower boom and the upper boom is changed by action of the cross link depending on a tilt angle of the lower boom, the upper boom is bent with respect to the lower boom so as to enable deep digging when the lower boom is maximally tilted down, and the upper boom is straightly extended with respect to the lower boom when the lower boom is maximally tilted up, enabling the bucket to be raised to a higher level. However, because the swing post is disposed in the front central portion of the upper structure as with general swing type excavators, the lower boom would hit against the cab if the lower boom is attempted to tilt rearwardly beyond its vertical posture. Hence the maximum tilt-up angle of the lower boom cannot be set to a large value. This results in a limitation in reducing a minimum turn radius of the front attachment given when the lower boom is maximally tilted up. Thus, the third prior art also has similar problems to those in the above swing type excavator having the mono-boom.

[0017] A first object of the present invention is to provide a swing type excavator which can realize the undercarriage-width turn without reducing not only the side ditch distance but also the maximum digging depth in a deep digging posture.

[0018] A second object of the present invention is to provide a swing type excavator which can realize the undercarriage-width turn with a simple construction without using a complex link mechanism, i.e., without so increasing weight of a front attachment.

[0019] A third object of the present invention is to provide a swing type excavator which can realize the undercarriage-width turn with a simple construction, and can easily avoid an interference between the front attachment and a cab when the front attachment is swung.

[0020] To achieve the above first object, according to the present invention, there is provided a swing type excavator comprising an undercarriage, an upper structure mounted on the undercarriage in a turnable manner, and a cab and a front attachment, including a bucket, an arm and a boom, both mounted on the upper structure, the upper structure being provided with a swing post which supports the boom of the front attachment in such a manner as able to swing the whole of the front attachment horizontally, wherein a coupling point between the boom and the swing post is positioned rearwardly of the swing center of the swing post away from the front attachment.

[0021] Preferably, said boom is a mono-boom.

[0022] Said boom may be a two-piece boom having a lower boom vertically tiltable by a boom cylinder with respect to said swing post and an upper boom vertically tiltable with respect to said lower boom.

[0023] Further, to achieve the above first to third

objects, according to the present invention, there is provided a swing type excavator having said two-piece boom wherein said front attachment includes opening angle adjustment means for changing a vertical opening angle between said lower boom and said upper boom depending on a vertical tilt angle of said lower boom, and that said swing post is mounted on said upper structure through a swing pin in a position forwardly and laterally of said cab so that said lower boom can be tilted rearwardly up to a position beyond a line laterally extending from a front part of said cab.

[0024] Preferably, said opening angle adjustment means comprises a cross link having one end coupled to said swing post through a horizontal pin and the other end coupled to said upper boom through a horizontal pin such that said cross link intersects a line connecting the coupling point between said lower boom and said swing post and a coupling point between said lower boom and said upper boom.

[0025] Preferably, said opening angle adjustment means comprises a hydraulic cylinder having one end coupled to said swing post or said lower boom through a horizontal pin and the other end coupled to said upper boom through a horizontal pin, and means for controlling extension and contraction of said hydraulic cylinder such that the opening angle between said lower boom and said upper boom is changed depending on the vertical tilt angle of said lower boom.

[0026] In the present invention concerning the above first object, the coupling point between the boom and the swing post is positioned rearwardly of the swing center of the swing post away from the front attachment. Therefore, the vertical tilt point of the boom and hence the front attachment comes closer to the turn center of the upper structure, and the minimum turn radius in the turning posture is reduced. Also, since the position of the swing post (i.e., the swing center) with respect to the upper structure is not required to be changed, the front attachment is not shifted toward the turn center of the upper structure when a side ditch is dug by turning the upper structure and swinging the whole of the front attachment in the opposite direction to the upper structure, and hence the same side ditch distance as in the prior art is ensured. Further, since the position of the swing post is not changed, the maximum tilt-down angle of the boom in the deep digging posture is also not changed and the same maximum digging depth as in the prior art is obtained.

[0027] Additionally, as a result of the vertical tilt center of the front attachment coming closer to the turn center of the upper structure, the maximum digging reach length from the turn center to the tip end of the bucket is shortened and hence the tipping moment in the maximum digging reach position is reduced to increase stability of the excavator.

[0028] In the present invention concerning the first to third objects, the boom is divided into the lower boom and the upper boom, and the opening angle between

the lower boom and the upper boom (hereinafter referred to as the boom-to-boom opening angle) is changed by the opening angle adjustment means depending on the vertical tilt angle of the lower boom so that the boom-to-boom opening angle is maximized in a turning posture where the lower boom is fully tilted up and the front attachment is folded. Also, the swing post is disposed on the upper structure in a position forwardly and laterally of the cab, allowing the lower boom to take an increased maximum tilt-up angle with no need of greatly changing layout, such as shifting the cab rearwardly, while preventing interference of the lower boom with the cab. Therefore, the minimum turn radius of the front attachment is so reduced as to enable the undercarriage-width turn. Thus, an ultra-small turn excavator capable of realizing the undercarriage-width turn can be obtained by employing a simple structure of the swing type, without using a complex parallel link mechanism. Also, if the swing post is only disposed in a position forwardly and laterally of the cab, there still exists a possibility that the bucket may hit against the cab when the boom is tilted up and the arm is folded in a condition where the swing post and the front attachment are swung perpendicularly to the cab on the same side. By increasing the boom-to-boom opening angle with tilting-up of the lower boom by the opening angle adjustment means, the bucket passes above the cab, thus eliminating a possibility that the bucket may hit against the cab.

[0029] With such a feature that the opening angle adjustment means comprises a cross link having one end coupled to the swing post through a horizontal pin and the other end coupled to the upper boom through a horizontal pin, the cross link being arranged to intersect a line connecting the coupling point between the lower boom and the swing post and the coupling point between the lower boom and the upper boom, the boom-to-boom opening angle in the maximum tilt-up position of the lower boom is so enlarged that the front attachment can take the turning posture narrower than the undercarriage width in that position of the lower boom.

[0030] In the above form, by setting the position of the coupling point between the cross link and the swing post to be rearwardly of the position of the coupling point between the lower boom and the swing post away from the front attachment, the boom-to-boom opening angle in the maximum digging reach position is reduced and a maximum digging reach length from the turn center to the tip end of the bucket is shortened. Furthermore, the boom-to-boom opening angle in the maximum tilt-down position of the lower boom is increased to enable deep digging.

[0031] As an alternative, the position of the coupling point between the cross link and the swing post is set to be forwardly of the position of the coupling point between the lower boom and the swing post toward the front attachment. This feature provides the following

advantage in addition to the advantages described above. Since the coupling position at one end of the cross link is located on the swing post forwardly of the coupling position of the lower boom, the longitudinal length of the swing post can be shortened and the entire size of the swing post itself can be reduced. Correspondingly, the degree of freedom in design is increased.

[0032] With another feature that the opening angle adjustment means comprises a hydraulic cylinder having one end coupled to the swing post or the lower boom through a horizontal pin and the other end coupled to the upper boom through a horizontal pin, and means for controlling extension and contraction of the hydraulic cylinder such that the opening angle between the lower boom and the upper boom is changed depending on the vertical tilt angle of the lower boom, the boom-to-boom opening angle can be changed depending on the vertical tilt angle of the lower boom. Additionally, in this case, the extension and contraction of the hydraulic cylinder can be changed at any desired rate, and hence the boom-to-boom opening angle can also be changed at any desired rate.

[0033] The term "generally within the undercarriage width" used in the specification means that the upper structure including the front attachment turns "within the undercarriage width" in a practical sense and, though depending on the machine size, it is allowed for the turning components to protrude from the undercarriage width (i.e., side ends of the undercarriage) on the order of several tens millimeters during use.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

Fig. 1 is a side view showing a construction of a swing type excavator according to one embodiment of the present invention.

Fig. 2 is a plan view of the excavator of Fig. 1.

Fig. 3 is a view for explaining operation of a front attachment in the excavator of Figs. 1 and 2, in which a cab is omitted and only its outer contour is indicated by two-dot-chain lines for the sake of simplicity.

Fig. 4 is a plan view of the excavator in a turning posture in Fig. 3.

Fig. 5A is an enlarged view of a swing post in the excavator of Figs. 1 and 2, and Fig. 5B is a view showing a comparative example in which a horizontal pin is positioned forwardly of a swing pin toward the front attachment.

Fig. 6 is a view for comparatively showing motions of the front attachments mounted to the respective swing posts in Figs. 5A and 5B, the view illustrating the cab in the simplified form as with Fig. 3.

Figs. 7A and 7B are plan views showing a condition of side ditch digging in which; Fig. 7A represents

the case of the embodiment shown in Fig. 5A and Fig. 7B represents the case of the comparative example shown in Fig. 5B.

Fig. 8 is a side view showing a construction and operation of a swing type excavator according to another embodiment of the present invention, the view illustrating the cab in the simplified form as with Fig. 3.

Fig. 9 is a side view showing a construction and operation of a swing type excavator according to still another embodiment of the present invention, the view illustrating the cab in the simplified form as with Fig. 3.

Fig. 10 is a block diagram of principal parts of a hydraulic circuit for an upper boom cylinder in Fig. 9.

Fig. 11 is a block diagram showing a configuration of a controller in Fig. 10.

Fig. 12 is a flowchart for control of an upper boom cylinder to be performed in the controller of Fig. 10.

Fig. 13 is a side view showing a modification of the excavator in Fig. 9 wherein an upper boom cylinder is coupled between a lower boom and an upper boom, the view illustrating the cab in the simplified form as with Fig. 3.

Fig. 14 is a view, similar to Fig. 1, showing an embodiment in which the present invention is applied to excavator having a canopy type cab.

Fig. 15 is a side view showing a construction of a swing type excavator according to yet another embodiment of the present invention.

Fig. 16A is an enlarged view of a swing post in the excavator of Fig. 15, and Fig. 16B is a view showing a comparative example in which a horizontal pin is positioned forwardly of a swing pin toward a front attachment.

Fig. 17 is a view for comparatively showing motions of the front attachments mounted to the respective swing posts in Figs. 16A and 16B, in which a cab is omitted and only its outer contour is indicated by two-dot-chain lines for the sake of simplicity.

Figs. 18A and 18B are plan views showing a condition of side ditch digging in which; Fig. 18A represents the case of the embodiment shown in Fig. 16A and Fig. 18B represents the case of the comparative example shown in Fig. 16B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] One embodiment of a swing type excavator according to the present invention will be described with reference to Figs. 1 to 7. The excavator of this embodiment is a ultra-small turn hydraulic shovel which can realize an undercarriage-width turn.

[0036] First, a construction of the excavator of this embodiment will be described. In the excavator of this embodiment, as shown in Figs. 1 and 2, an upper struc-

ture 11 is mounted on an undercarriage 10 which travels to move an excavator body, and a cab 12 is mounted on the upper structure 11 in its one side. A swing post 13 is attached by a swing pin 30, as a vertical pin, to the upper structure 11 at a position forwardly and laterally of the cab 12. A front attachment 1, including a bucket 22, an arm 19, an upper boom 17, a lower boom 14 and a cross link 15, is mounted to the swing post 13. The swing post 13 is swingable in the horizontal direction about the swing pin 30. As well known, a seat, various control levers and so on are installed in the cab 12.

[0037] The upper structure 11 has such a size that it can swing generally within a width of the undercarriage 10, and is operated by a turning mechanism (not shown) so as to turn horizontally. In addition to the cab 12, the swing post 13 and the front attachment 1 mentioned above, all kinds of equipment necessary for a typical hydraulic shovel or excavator, e.g., hydraulic devices such as hydraulic pumps and valves for driving a boom cylinder 16, an arm cylinder 18, a bucket cylinder 20 and a swing cylinder 23, which will be described later, an engine, etc. are also mounted on the upper structure 11.

[0038] The boom is divided into two parts, i.e., the lower boom 14 and the upper boom 17. The lower boom 14 has a foot end coupled to the swing post 13 by a horizontal pin 31, and a distal end coupled to the upper boom 17 by a horizontal pin 32. Also, the boom cylinder 16 has a bottom-side end coupled to the swing post 13 by a horizontal pin 16A, and a rod distal end coupled to the lower boom 14 by a horizontal pin 16B, thereby tilting the lower boom 14 vertically upon its extension and contraction. Thus, the boom cylinder 16 serve as a power source to tilt the lower boom 14. On the other hand, the upper boom 17 has a bottom end coupled to the lower boom 14 by the horizontal pin 32 as mentioned above, and a distal end coupled to the arm 19 by a horizontal pin 33. Additionally, the cross link 15, described later, is coupled to the upper boom 17 by a horizontal pin 34.

[0039] Here, a tilt angle of the lower boom 14 is maximized in the upward direction when the boom cylinder 16 is extended to a maximum, and is maximized in the downward direction when the boom cylinder 16 is contracted to a minimum. Also, as the tilt angle in the upward direction is increased, the lower boom 14 is gradually inclined rearwardly beyond its vertical posture. In the conventional swing type excavator, since the swing post is mounted centrally of the upper structure in front of the cab, there is a possibility that the lower boom 14 may hit against the cab when the lower boom 14 is inclined rearwardly beyond its vertical posture. Therefore, the maximum tilt-up angle of the lower boom 14 has been limited to such an extent that the lower boom 14 will not be inclined rearwardly up to a position of the cab. In this embodiment, since the swing post 13 is disposed in a position forwardly and laterally of the cab 12, the lower boom 14 will not hit against the cab 12 even

when the lower boom 14 is inclined rearwardly to a large extent. Accordingly, the maximum tilt-up angle of the lower boom 14 given when the boom cylinder 16 is maximally extended is set in this embodiment so that the lower boom 14 may be inclined up to a position where it interferes with the cab 12 in the prior art, i.e., the lower boom 14 may be inclined rearwardly up to a position exceeding a line laterally extended from the cab 12. That setting is realized by properly designing a maximum stroke of the boom cylinder 16 given when it is maximally extended, and its mount relation with respect to the swing post 13.

[0040] In the swing post 13, the horizontal pin 31 as a coupling point between the lower boom 14 and the swing post 13 is positioned rearwardly of the swing pin 30 as the swing center of the swing post 13 away from the front attachment 1.

[0041] The cross link 15 is a member constituting an opening angle adjustment means, and has one end coupled to the swing post 13 by a horizontal pin 35, and the other end coupled to the upper boom 17 by the horizontal pin 34. In the swing post 13, the horizontal pin 35 at one end of the cross link 15 is positioned rearwardly of the horizontal pin 31 at the foot end of the lower boom 14 away from the front attachment 1. In the posture shown in Fig. 1, the cross link 15 intersects a straight line connecting the horizontal pin 32 by which the upper boom 17 and the lower boom 14 are coupled to each other and the horizontal pin 31 by which the lower boom 14 and the swing post 13 are coupled to each other.

[0042] The cross link 15 serves to, as described later in detail, change an opening angle between the upper boom 17 and the lower boom 14 to be maximized when the lower boom 14 is maximally tilted up such that the lower boom 14 is inclined rearwardly beyond the line laterally extended from the cab 12. That maximum opening angle is set so as to provide the minimum turn radius of the front attachment 1 which is generally equal to or smaller than the width of the undercarriage 10 on condition that the lower boom 14 is inclined rearwardly beyond the line laterally extended from the cab 12.

[0043] The arm 19 is vertically tiltably coupled to the distal end of the upper boom 17 by the horizontal pin 33 as described above, and the bucket 22 is vertically tiltably coupled to a distal end of the arm 19 through bucket links 21. The arm cylinder 18 is attached between the upper boom 17 and the arm 19 by horizontal pins 36, 37. An opening angle between the arm 19 and the upper boom 17 is changed upon the arm cylinder 18 being extended and contracted. Also, the bucket cylinder 20 is attached between the arm 19 and the bucket links 21 by horizontal pins 38, 39. The bucket links 21 are moved with extension and contraction of the bucket cylinder 20, whereupon the bucket 22 is angularly moved about its coupling point to the arm 19 to thereby dig earth and sand, etc. Thus, the arm cylinder 18 and the bucket cylinder 20 serve as power sources to angularly move the arm 19 and the bucket 22, respectively.

[0044] Furthermore, the swing cylinder 23 has a rod distal end coupled to the swing post 13 by a vertical pin 23a, and a bottom-side end coupled to a predetermined position on the upper structure 11 by a vertical pin 23b. When the swing cylinder 23 is extended and contracted as indicated by broken lines in Fig. 23, the swing post 13 is swung correspondingly as indicated by broken lines, and the front attachment 1 is also swung with respect to the upper structure 11 (see Fig. 2). When digging a side ditch by the excavator of this embodiment, the upper structure 11 is turned and the swing cylinder 23 is selectively extended or contracted, thereby swinging the swing post 13 and hence the front attachment 1 in the opposite direction to the upper structure 11, as with conventional swing type excavators.

[0045] Operation of the excavator of this embodiment will be described below with reference to Figs. 3 and 4 while focusing primarily on action of the cross link 15.

[0046] In Fig. 3, when the boom cylinder 16 is extended and contracted, the lower boom 14 is vertically tilted about the horizontal pin 31 as its coupling point to the swing post 13. Since the upper boom 17 is coupled to the lower boom 14 by the horizontal pin 32 and the cross link 15 is coupled to the upper boom 17 by the horizontal pin 32, the opening angle between the upper boom 17 and the lower boom 14 is changed depending on movement of the lower boom 14.

[0047] The horizontal pin 32 at the distal end of the lower boom 14 moves along a path A which is a circle (indicated by one-dot-chain line in Fig. 3) with the horizontal pin 31 at the foot end of the lower boom 14 as the center, and the horizontal pin 34 at the distal end of the cross link 15 moves along a path B which is a circle (indicated by two-dot-chain line in Fig. 3) with the horizontal pin 35 at one end of the cross link 15 as the center. For reference, a path C of the horizontal pin 33 coupling the upper boom 17 and the arm 19 is also shown in Fig. 3. The cross link 15 is designed such that the cross link 15 intersects the straight line connecting the horizontal pin 32 and the horizontal pin 31 in the posture of Fig. 1, and the path A of the horizontal pin 32 at the distal end of the lower boom 14 is overlapped with the path B of the horizontal pin 34 at the distal end of the cross link 15 as shown in Fig. 3. With this arrangement, when the path B of the horizontal pin 34 at the distal end of the cross link 15 is positioned outside the path A of the horizontal pin 32 at the distal end of the lower boom 14, the boom-to-boom opening angle is increased as the spacing between the paths A and B is enlarged. Conversely, when the path B of the horizontal pin 34 at the distal end of the cross link 15 is positioned inside the path A of the horizontal pin 32 at the distal end of the lower boom 14, the boom-to-boom opening angle is reduced as the spacing between the paths A and B is enlarged. By so setting the positional relationship between the cross link 15 and the lower boom 14, the boom-to-boom opening angle can be controlled to a desired value.

[0048] More specifically, in a region (indicated by I in Fig. 3) including the maximum tilt-up angle of the lower boom 14 given when the boom cylinder 16 is extended to a maximum, the boom-to-boom opening angle is increased as the lower boom 14 is tilted upwardly. Also, in a region (indicated by II in Fig. 3) including the maximum tilt-down angle of the lower boom 14 given when the boom cylinder 16 is contracted to a minimum, the boom-to-boom opening angle is increased as the lower boom 14 is tilted downwardly. The boom-to-boom opening angle is minimized when the tilt angle of the lower boom 14 is a predetermined angle ϕ from the horizontal direction, i.e., at the boundary between the first region and the second region. In Fig. 3, the tilt angle of the lower boom 14 in a maximum digging reach position, where the front attachment 1 is maximally extended along the ground surface, is in the vicinity of the predetermined angle ϕ .

[0049] Assuming now in Fig. 3 that the boom-to-boom opening angle in the turning posture where the lower boom 14 takes the maximum tilt-up angle is α , the boom-to-boom opening angle in the maximum digging reach position, where the front attachment is maximally extended along the ground surface is β , and the boom-to-boom opening angle in a deep digging posture where the upper boom 17 is substantially vertical to the ground surface is γ , there holds a relationship of:

$$\alpha > \gamma > \beta \quad (1)$$

[0050] Therefore, when the lower boom 14 is pivotally raised to assume the turning posture, the boom-to-boom opening angle is increased by the action of the cross link 15 so that the lower boom 14 and the upper boom 17 are gradually angularly spaced above the upper structure 11. At this time, when the boom cylinder 16 is maximally extended to maximize the tilt-up angle of the lower boom 14, the boom-to-boom opening angle is also maximized by the action of the cross link 15. Then, since the lower boom 14 is inclined rearwardly beyond the vertical position as described above, the front attachment 1 is accommodated within the width of the undercarriage 10 by extending the arm cylinder 18 and the bucket cylinder 20 to such an extent that the arm 19 and the bucket 22 are folded to locate near the upper boom 17 as shown. Fig. 4 shows the excavator in this condition as viewed from above. When the lower boom 14 is pivotally lowered from the turning position, the boom-to-boom opening angle is gradually reduced by the action of the cross link 15 and, in the maximum digging reach position, the maximum digging reach length from the turn center to a tip end of the bucket 22 is shortened. Accordingly, the tipping moment in the maximum digging reach position is reduced to increase stability of the excavator. In the deep digging posture where the lower boom 14 is further pivotally lowered, the boom-to-boom opening angle is increased again and the bucket 22 is moved to a deeper position for

deep digging.

[0051] While, in this embodiment, the tilt angle β of the lower boom 14 in the maximum digging reach position of the front attachment 1 is not coincident with the predetermined angle ϕ where boom-to-boom the opening angle is minimized, these angles may be set to be substantially equal to each other. By so setting, the maximum digging reach length takes a minimum value and the effect of improving stability is maximized.

[0052] In the swing post 13 of the excavator of this embodiment, as described above, the coupling point between the lower boom 14 and the swing post 13 is positioned rearwardly of the swing center of the swing post 13 away from the front attachment 1. Fig. 5A is an enlarged view showing such an arrangement. On the contrary, Fig. 5B is an enlarged view showing a comparative example in which a horizontal pin 31a as the coupling point between a lower boom 14a and a swing post 13a is positioned forwardly of a swing pin 30a as the swing center of the swing post 13a toward a front attachment. Note that the swing post 13a is disposed on the upper structure in the same position as the swing post 13. In both the cases of Figs. 5A and 5B, the horizontal pins 16A, 16C coupling the bottom-side ends of the boom cylinders 16, 16a to the swing posts 13, 13a are positioned forwardly of the swing pins 30, 30a. In the conventional swing type excavator, as with the case of Fig. 5A, the coupling point between the boom and the swing post is positioned forwardly of the swing center of the swing post toward the front attachment.

[0053] Fig. 6 comparatively shows motions of the front attachments mounted to the swing posts in Figs. 5A and 5B. In Fig. 6, solid lines represent the motion of the front attachment in this embodiment of Fig. 5A and two-dot-chain lines represent the motion of the front attachment in the comparative example of Fig. 5B. With the arrangement of this embodiment that the vertical tilt center of the lower boom 14 is positioned rearwardly of the swing center of the swing post 13 away from the front attachment 1, the vertical tilt center of the front attachment 1, including the lower boom 14, comes closer to the turn center of the upper structure 11. Accordingly, the minimum turn radius is reduced in the amount corresponding to a shortened length a shown in Fig. 6. Further, corresponding to the shortened length a, an increase in the boom-to-boom opening angle necessary for keeping the front attachment 1 within the undercarriage width is reduced and the burden imposed on the cross link is diminished. Moreover, as a result of the vertical tilt center of the front attachment 1 coming closer to the turn center of the upper structure 11, the maximum digging reach length from the turn center to the tip end of the bucket 22 is reduced by a shortened length b shown in Fig. 6. Therefore, the tipping moment in the maximum digging reach position is further reduced to ensure higher stability of the excavator.

[0054] Figs. 7A and 7B show the excavator in a condition of side ditch digging in which; Fig. 7A represents

the case of this embodiment shown in Fig. 5A and Fig. 7B represents the case of the comparative example shown in Fig. 5B. For any case, in the illustrated condition, the upper structure 11 is turned 90° clockwise on the drawing and the front attachment is swung 90° counterclockwise on the drawing to dig a side ditch in a limit position maximally shifted in the direction of the undercarriage width. Note that, in Fig. 7B, identical members to those in Fig. 7A are denoted by the same reference numerals. While the vertical tilt center of the lower boom 14 (i.e., the position of the horizontal pin 31 or 31a) is located on the drawing lower in this embodiment of Fig. 7A than in the comparative example of Fig. 7B, the swing center of the swing post 13 (i.e., the position of the swing pin) is in the same position. Accordingly, the side ditch distance δ is the same in both the cases of Figs. 7A and 7B. Thus, since the swing center position of the swing post 13 is not changed, the side ditch can be dug in a position transversely spaced from the longitudinal center of the excavator body by a distance comparable to that achieved in the prior art, and hence the side ditch distance is not sacrificed.

[0055] Additionally, as seen from Fig. 6, since the vertical tilt center of the lower boom 14 is positioned closer to the turn center of the upper structure 11 and the lower boom 14 is allowed to move rearwardly up to a position more away from the front attachment 1, a space left open in front of the lower boom is increased. Therefore, when loading dug earth and sand, etc. on a dump track or the like from the bucket 22, the earth and sand, etc. can be more easily loaded.

[0056] It is to be noted that the positional relationship between the horizontal pin 16A at the foot end of the boom cylinder 16 and the swing pin 30 is not limited to that shown in Figs. 5A and 5B, but may be optionally set.

[0057] With this embodiment described above, the boom comprises the lower boom 14 and the upper boom 17, and the boom-to-boom opening angle is changed by the action of the cross link 15 depending on the tilt angle of the lower boom 14 so that the opening angle is maximized in the turning posture where the lower boom 14 is tilted up to a maximum. Also, since the swing post 13 is disposed in a position forwardly and laterally of the cab 12, the lower boom can take an increased maximum tilt-up angle with no need of shifting the cab 12 rearwardly, while preventing interference of the lower boom 14 with the cab 12. Therefore, the minimum turn radius of the front attachment 1 is so reduced as to enable the undercarriage-width turn. Thus, a ultra-small turn excavator capable of realizing the undercarriage-width turn can be obtained by employing a simple structure of the swing type, without using a complex parallel link mechanism. Also, in realizing the undercarriage-width turn, the degree of freedom in designing layout of the cab 12 on the narrow upper structure 11 can be increased. For example, the cab 12 may be installed in a more forward position than usual.

This is advantageous in that the engine size can be increased correspondingly, which provides a greater allowance in design of the upper structure.

[0058] If the swing post is only disposed in a position forwardly and laterally of the cab, there still exists a possibility that the bucket may hit against the cab when the boom is tilted up and the arm is folded in a condition where the swing post and the front attachment are swung perpendicularly to the cab on the same side. However, this embodiment is also effective to avoid such a possibility. More specifically, since the cross link 15 is provided in such a manner as to increase the opening angle between the upper boom 17 and the lower boom 14 with tilting-up of the lower boom 14, the bucket 22 passes above the cab 12 when the lower boom 14 is tilted up and the arm 19 is folded in the condition where the swing post 13 and the front attachment 1 are swung perpendicularly to the cab 12 on the same side. As a result, a possibility that the bucket 22 may hit against the cab 12 is eliminated.

[0059] Further, since the cross link 15 is arranged such that one end thereof is coupled to the swing post 13 through the horizontal pin 35, the distal end thereof is coupled to the upper boom 17 through the horizontal pin 32, and it intersects the straight line connecting the horizontal pin 32 and the horizontal pin 31, the boom-to-boom opening angle in the maximum tilt-up position of the lower boom 14 is so enlarged that the front attachment can take the turning posture narrower than the undercarriage width in that position of the lower boom.

[0060] Since the horizontal pin 35 at one end of the cross link 15 is disposed rearwardly of the horizontal pin 31 at the foot end of the lower boom 14 away from the front attachment 1, the boom-to-boom opening angle is reduced in the maximum digging reach position where the lower boom 14 is tilted down, and the tipping moment in the maximum digging reach position is reduced to increase stability of the excavator. Additionally, in the deep digging posture where the lower boom 14 is further pivotally lowered, the boom-to-boom opening angle is increased so as to enable deep digging.

[0061] Since the coupling point between the lower boom 14 and the swing post 13 is positioned rearwardly of the swing center of the swing post 13 away from the front attachment 1, the minimum turn radius is further reduced and an increase in the boom-to-boom opening angle necessary for keeping the front attachment 1 within the undercarriage width is reduced correspondingly to diminish the burden imposed on the cross link 15. Also, the maximum digging reach length is shortened and the tipping moment in the maximum digging reach position is further reduced to ensure higher stability of the excavator. Moreover, since the swing center of the swing post 13 is not changed, the side ditch distance is not sacrificed. Additionally, when loading dug earth and sand, etc. on a dump track or the like from the bucket 22, the earth and sand, etc. can be more easily loaded because of an increased space left open in front

of the lower boom.

[0062] Since this embodiment of the swing type does not employ a heavy mechanism required for the offset type, the weight of the front attachment is reduced and the stability is increased. Also, since the counterweight can be made smaller correspondingly, it is possible to reduce the total weight of the excavator body and hence a transportation cost. The reduced weight of the excavator body results in other advantages of reducing a necessary engine output, cutting down a manufacture cost and a running cost, and improving fuel economy.

[0063] Further, since this embodiment is not of the offset type, the number of connection points where vertical pins are used is reduced, whereby the front attachment is not subject to such restrictions as imposed on conventional offset type excavators and application fields are widened. Additionally, since there is no fear of interference between a lower portion of the parallel link mechanism and the ground surface during side ditch digging, the digging depth can be increased as compared with standard type excavators. As a result of using no complex parallel link mechanism, the manufacture cost is reduced and maintenance work is less frequently required.

[0064] In offset type excavators, when the arm and the bucket are offset to the side opposite to the cab, the field of view may be obstructed by the boom, giving an operator difficulty in viewing the digging position from the cab. However, since this embodiment is of the swing type that the front attachment 1 is mounted to the swing post 13, the field of view from the cab 12 is widened, thus allowing the operator to surely look at the bucket. Accordingly, the operator can perform work with confidence and hence safety is improved as compared with the offset type excavators.

[0065] In addition, since this embodiment is not of the offset type, there is no possibility that the front attachment 1 may badly interfere with the cab 12. Only when the front attachment 1 is swung to the side opposite to the cab 12 and the lower boom 14 is tilted upwardly, there is a possibility that the front attachment 1 slightly interferes with the cab 12, but an interference preventing area can be easily calculated just by detecting a vertical tilt angle and a swing angle of the lower boom 14. Unlike the conventional offset type excavators, therefore, an inexpensive and highly reliable interference preventing device can be realized with no need of detecting angles of all components of the front attachment in the ultra-small turn excavator.

[0066] Next, another embodiment of the swing type excavator according to the present invention will be described with reference to Fig. 8. Note that, in Fig. 8, identical members to those in Figs. 1 to 3 are denoted by the same reference numerals.

[0067] As shown in Fig. 8, in a swing post 13A of this embodiment, since a horizontal pin 35A at one end of a cross link 15A is positioned rearwardly of a horizontal pin 31A at a foot end of a lower boom 14A and, in the

posture shown in Fig. 8, the cross link 15A intersects a straight line connecting a horizontal pin 32A by which the upper boom 17 and the lower boom 14A are coupled to each other and the horizontal pin 31A at which the lower boom 14 and the swing post 13A are coupled to each other.

[0068] The horizontal pin 32A at the distal end of the lower boom 14A moves along a path which is a circle (indicated by one-dot-chain line in Fig. 8) with the horizontal pin 31A as the center, and the horizontal pin 34A at the distal end of the cross link 15A moves along a path which is a circle (indicated by two-dot-chain line in Fig. 8) with the horizontal pin 35A as the center. In this embodiment, the path of the horizontal pin 32A at the distal end of the lower boom 14A is overlapped with the path of the horizontal pin 34A at the distal end of the cross link 15A as shown in Fig. 8. As with the embodiment of Fig. 3, therefore, when the path of the horizontal pin 34A at the distal end of the cross link 15A is positioned outside the path of the horizontal pin 32A at the distal end of the lower boom 14A, the boom-to-boom opening angle is gradually increased. In the region where the positional relationship is reversed to the above, the boom-to-boom opening angle is gradually reduced.

[0069] Accordingly, when the lower boom 14 is pivotally raised to assume the turning posture, the boom-to-boom opening angle is gradually increased by the action of the cross link 15A and, when it is pivotally lowered from the turning position, the boom-to-boom opening angle is gradually reduced by the action of the cross link 15. In this embodiment, the opening angle α in the turning posture, the opening angle β in the maximum digging reach position, and the opening angle γ in the deep digging posture are related to each other as follows:

$$\alpha > \beta > \gamma \quad (2)$$

[0070] As with the above embodiment, when the lower boom 14 is pivotally lowered from the turning position, the boom-to-boom opening angle is gradually reduced and, in the maximum digging reach position, the maximum digging reach length from the turn center to the tip end of the bucket 22 is shortened. Therefore, the tipping moment in the maximum digging reach position is reduced to increase stability of the excavator. Note that, so long as the boom-to-boom opening angle is increased in the turning posture, the magnitude relationship among α , β and γ may be optionally set to prolong the maximum digging reach length, for example, by adjusting the position of the horizontal pin 35 of the cross link 15 and the length of the cross link 15.

[0071] With this embodiment thus arranged, since the coupling position (i.e., the horizontal pin 35A) at one end of the cross link 15A is positioned forwardly of the coupling position (i.e., the horizontal pin 31A) of the lower boom 14A to the swing post 13A, the longitudinal

length of the swing post 13A can be shortened. Thus, the size of the swing post 13A itself is reduced and the degree of freedom in design is increased correspondingly.

[0072] Further, in the maximum digging reach position, the maximum digging reach length is shortened and the tipping moment is reduced to increase stability of the excavator like the above embodiment.

[0073] Next, still another embodiment of the swing type excavator according to the present invention will be described with reference to Figs. 9 to 12. Note that, in Fig. 9, identical members to those in Fig. 1 are denoted by the same reference numerals.

[0074] As shown in Fig. 9, in this embodiment, an upper boom cylinder 40 is employed as opening angle adjustment means instead of the cross link in Figs. 1 and 8. Specifically, the upper boom cylinder 40 is coupled between the swing post 13 and the upper boom 17 to generate force, when extended and contracted, for changing the opening angle between the upper boom 17 and the lower boom 14 (hereinafter referred to as the boom-to-boom opening angle). The remaining construction is the same as in Figs. 1 and 8.

[0075] Fig. 10 is a block diagram of principal parts of a hydraulic circuit as means for controlling extension and contraction of the upper boom cylinder 40 in this embodiment. In Fig. 10, a sensor 41 detects an elevation angle (vertical tilt angle) θ of the lower boom, and a sensor 42 detects a boom-to-boom opening angle ε . A controller 43 receives the angles θ and ε from the sensors 41 and 42, respectively, and applies to an amplifier 44 a voltage signal 43a corresponding to a flow rate supplied to the upper boom cylinder 40. The amplifier 44 converts the voltage signal 43a into a current signal 44a, and the shift position of a directional control valve 45 is determined by the current signal 44a. Depending on the shift position of the directional control valve 45, a hydraulic fluid delivered under pressure from a reservoir 46 by a hydraulic pump 47 is supplied at a certain rate to a rod-side port 40a or a bottom-side port 40b of the upper boom cylinder 40, thereby contracting or extending the upper boom cylinder 40. Also, a certain back pressure is applied to the circuit by a back pressure valve 48.

[0076] As shown in Fig. 11, the controller 43 comprises an arithmetic unit 43A, a first memory 43B and a second memory 43C. The first memory 43B stores the value of a boom-to-boom opening angle θ_0 at the start of work, and the second memory 43C is a function memory for storing a function table which represents the relationship between the angles θ and ε . In the controller 43, the detected angles θ and ε are input to the arithmetic unit 43A which calculates the voltage signal 43a corresponding to a flow rate supplied to the upper boom cylinder 40 while transferring data with respect to the first memory 43B and the second memory 43C.

[0077] A control flow for the upper boom cylinder 40 to be executed in the controller 43 will now be described

with reference to Fig. 12. It is to be noted that the following calculation and control procedures are executed by slicing a period of time, during which the excavator is operating, into a predetermined sampling time Δt . First, in step S1, an initial value of the elevation angle of the lower boom 14 prior to starting to operate the lower boom 14 is input and stored as θ_0 in the first memory 43B beforehand. Then, it is determined in step S2 whether the time Δt has elapsed or not after the start of operation. If Δt has elapsed, the control flow goes to next step S3.

[0078] In step S3, the elevation angle θ of the lower boom 14 and the boom-to-boom opening angle ε are detected by the sensors 41 and 42, respectively, and the arithmetic unit 43A reads both the angles. Then, in step S4, the arithmetic unit 43A reads the previous elevation angle θ_0 of the lower boom 14 (before the time Δt) from the first memory 43B. Subsequently, in step S5, an elevation angle (hereinafter denoted by $[\theta]$) after Δt from the current time is calculated. Here, $[\theta]$ is expressed by:

$$[\theta] = 2\theta - \theta_0 \quad (3)$$

This equation is resulted as follows. Given an elevation angular speed of the lower boom 14 being θ^* , since θ^* is expressed by;

$$\theta^* = (\theta - \theta_0)/\Delta t \quad (4)$$

the following equation is obtained:

$$[\theta] = \theta + \theta^* \cdot \Delta t = 2\theta - \theta_0 \quad (5)$$

[0079] Thereafter, in step S6, the arithmetic unit 43A reads $[\varepsilon]$ corresponding to the above $[\theta]$, i.e., a boom-to-boom opening angle after Δt from the current time, from the function table in the second memory 43C. In step S7, θ_0 in the first memory 43B is replaced by θ which is stored as new θ_0 . Then, in step S8, a boom-to-boom opening angular speed $[\varepsilon^*]$ after Δt from the current time is calculated from:

$$[\varepsilon^*] = ([\varepsilon] - \varepsilon)/\Delta t \quad (6)$$

[0080] In next step S9, an extending or contracting speed of the upper boom cylinder 40 is calculated from $[\varepsilon^*]$ by utilizing a geometrical relation formula. This geometrical relation formula is uniquely determined by the lengths and positions of the upper boom cylinder 40 and the lower boom 14, the coupling positions of the upper boom cylinder 40 and the lower boom 14 to the swing post 13, etc., and is stored in the arithmetic unit 43A. In next step S10, a flow rate of the hydraulic fluid to be supplied to the upper boom cylinder 40 is calculated from the extending or contracting speed of the upper boom cylinder 40, followed by outputting the calculated result (i.e., the voltage signal 43a) to the amplifier 44 in step S11. It is then determined in step S12 whether the

operation is to be completed or not. If so, the control flow is ended, but if not so, it is returned to step S1 to repeat the same procedures as described above.

[0081] With this embodiment thus arranged, the boom-to-boom opening angle is changed depending on the vertical tilt angle of the lower boom 14 by means of the upper boom cylinder 40, the controller 43 for controlling extension and contraction of the cylinder 40, and so on. Additionally, the extension and contraction of the upper boom cylinder 40 can be changed at any desired rate, and hence the boom-to-boom opening angle can also be changed at any desired rate.

[0082] As a modification of the above embodiment, an upper boom cylinder 50 may be coupled between the lower boom 14 and the upper boom 17 as shown in Fig. 13. This modification can also provide similar advantages. Note that, in Fig. 13, identical members to those in Fig. 9 are denoted by the same reference numerals.

[0083] While, in the foregoing embodiments, the present invention is applied to the excavator having the closed type cab, it is also applicable to an excavator having a canopy type cab which is partly open. Fig. 14 shows such an embodiment in which a cab 12A is of the canopy type having only a roof 12B and being open to both sides. In the canopy type cab 12A, a seat, various control levers and so on are similarly installed in a space below the roof 12A. In the excavator of Fig. 14, the remaining construction is the same as in the embodiment of Fig. 1. This modification can also provide similar advantages to those in the embodiment of Fig. 1.

[0084] In each of the embodiments described before, the swing post 13 is disposed on the upper structure 11 in a position forwardly and laterally of the cab 12. This, however, is only illustrative and the arrangement may be modified such that the right front corner of the cab is cut-away so as to provide a space for accommodating the swing post 13. The present invention can be applied also to such a modification, without impairing the advantages described before.

[0085] A swing type excavator according to yet another embodiment of the present invention will be described with reference to Figs. 15 to 18. The excavator of this embodiment is a hydraulic shovel which can realize the ultra-small turn.

[0086] In Fig. 15, the excavator of this embodiment comprises an undercarriage 110 which travels to move an excavator body, and an upper structure 111 which is mounted on the undercarriage 110, with a closed type cab 112 mounted on the upper structure 111. A swing post 113 is attached by a swing pin 130, as a vertical pin, to the upper structure 111 at a central position forwardly of the cab 112 in a horizontally swingable manner. A front attachment 101, including a bucket 122, an arm 119 and a boom 114, is mounted to the swing post 113. A blade 102 is provided so as to project forwardly of the undercarriage 110. The cab 112 may be of the canopy type having only a roof. As well known, a driving seat, various control levers and so on are installed in the

cab 112.

[0087] The upper structure 111 is able to turn horizontally on the undercarriage 110 by a turning mechanism (not shown). In addition to the cab 112, the swing post 113 and the front attachment 101 mentioned above, all kinds of equipment necessary for a typical hydraulic shovel or excavator, e.g., hydraulic devices such as hydraulic pumps and valves for driving a boom cylinder 116, an arm cylinder 118, a bucket cylinder 120 and a swing cylinder 123, which will be described later, an engine, etc. are also mounted on the upper structure 111.

[0088] The boom 114 is a mono-boom vertically bent at a certain angle, and has a foot end coupled to the swing post 113 by a horizontal pin 131. Also, the boom cylinder 116 has a bottom-side end coupled to the swing post 113 by a horizontal pin 116A, and a rod-side end coupled by a horizontal pin 116B to a bracket 114A which is fixed to an inner bent portion of the boom 14, thereby tilting the lower boom 114 vertically upon its extension and contraction. Thus, the boom cylinder 116 serve as a power source to tilt the boom 114.

[0089] The arm 119 is vertically tiltably coupled to a distal end of the boom 114 by a horizontal pin 133, and the bucket 122 is vertically tiltably coupled to a distal end of the arm 119 through bucket links 121. The arm cylinder 118 is attached between a bracket 114B fixed to an outer bent portion of the boom 114 and the arm 119 by horizontal pins 136, 137. An angle formed between the arm 119 and the boom 114 is changed upon the arm cylinder 118 being extended and contracted. Also, the bucket cylinder 120 is attached between the arm 119 and the bucket links 121 by horizontal pins 138, 139. The bucket links 121 are moved with extension and contraction of the bucket cylinder 120, whereupon the bucket 122 is angularly moved about its coupling point to the arm 119 to thereby dig earth and sand, etc. Thus, the arm cylinder 118 and the bucket cylinder 120 serve as power sources to angularly move the arm 119 and the bucket 122, respectively.

[0090] In the swing post 113, the horizontal pin 131 as a coupling point between the boom 114 and the swing post 113 is positioned rearwardly of the swing pin 130 as the swing center of the swing post 113 away from the front attachment 101.

[0091] Furthermore, the swing cylinder 123 has a rod-side end coupled to the swing post 113 by a vertical pin 123a, and a bottom-side end coupled to a predetermined position on the upper structure 111 by a vertical pin 123b (see Fig. 17). When the swing cylinder 123 is extended and contracted, the swing post 113 is swung correspondingly and the front attachment 101 is entirely swung in the horizontal direction with respect to the upper structure 111. When digging a side ditch, the upper structure 111 is turned and the swing cylinder 123 is extended or contracted depending on the direction of the turn, thereby swinging the swing post 113 and hence the front attachment 101 in the opposite direction

to the upper structure 111.

[0092] Operation of the thus-constructed excavator of this embodiment will be described below. In the swing post 113 of the excavator of this embodiment, as mentioned above, the coupling point between the boom 114 and the swing post 113 is positioned rearwardly of the swing center of the swing post 113 away from the front attachment 101. Fig. 16A is an enlarged view showing the swing post 113 and thereabout in this embodiment, whereas Fig. 16B is an enlarged view showing a swing post and thereabout in the prior art as a comparative example. In the comparative example, a horizontal pin 131a as the coupling point between a boom 114a and a swing post 113a is positioned forwardly of a swing pin 130a as the swing center of the swing post 113a toward a front attachment. Note that, in both the cases of Figs. 16A and 16B, the horizontal pins 116A, 116C coupling the bottom-side ends of the boom cylinders 116, 116a to the swing posts 113, 113a are positioned forwardly of the swing pins 130, 130a.

[0093] Fig. 17 shows motions of the front attachments mounted to the swing posts in Figs. 16A and 16B. In Fig. 17, solid lines represent the motion of the front attachment in this embodiment of Fig. 16A and two-dot-chain lines represent the motion of the front attachment in the comparative example of Fig. 16B. As will be seen from Fig. 17, with the arrangement of this embodiment that the vertical tilt center of the boom 114 is positioned rearwardly of the swing center of the swing post 113 away from the front attachment 101, the vertical tilt center of the front attachment 101, including the boom 114, comes closer to the turn center of the upper structure 111. Accordingly, the minimum turn radius of the front attachment in its turning posture is reduced in the amount corresponding to a shortened length a shown in Fig. 17.

[0094] Also, as shown in Fig. 16, the swing pin 130 of this embodiment is disposed on the upper structure in the same position as the swing pin 130a of the prior art. Therefore, even when the maximum tilt-down angle of the boom 114 in the deep digging posture is set to a value equal to that in the prior art, the boom cylinder 116 will not interfere with the blade 102 and, as seen from Fig. 17, the same maximum digging depth as in the prior art is obtained. Moreover, as a result of the vertical tilt center of the front attachment 101 coming closer to the turn center of the upper structure 111, the maximum digging reach length from the turn center to a tip end of the bucket 122 is reduced by a shortened length b shown in Fig. 17. Therefore, the tipping moment in the maximum digging reach position is reduced to increase stability of the excavator.

[0095] Figs. 18A and 18B show the excavator in a condition of side ditch digging in which; Fig. 18A represents the case of this embodiment shown in Fig. 16A and Fig. 18B represents the case of the comparative example shown in Fig. 16B. For any case, in the illustrated condition, the upper structure 111 is turned 90° clockwise on

the drawing and the front attachment is swung 90° counterclockwise on the drawing to dig a side ditch in a limit position maximally shifted in the direction of the undercarriage width.

[0096] In this embodiment shown in Fig. 18A, the vertical tilt center of the front attachment 101 is closer to the turn center of the upper structure 111 and, therefore, the vertical tilt center of the boom 114 (i.e., the position of the horizontal pin 131) is located on the drawing lower than in the comparative example of Fig. 18B. But, since the swing center of the swing post 113 (i.e., the position of the swing pin) is in the same position, the front attachment itself does not move toward the turn center of the upper structure 111 in the condition of side ditch digging. Accordingly, the side ditch distance δ from an outer lateral surface of the undercarriage 110 to an outer wall surface of the side ditch is the same in both the cases of Figs. 18A and 18B. Thus, with this embodiment, the side ditch can be dug in a position transversely spaced from the longitudinal center of the excavator body by a distance comparable to that achieved in the prior art.

[0097] Additionally, in the posture shown in Fig. 17, since the vertical tilt center of the boom 114 is positioned closer to the turn center of the upper structure 111 and the front attachment 101 is allowed to entirely move toward the turn center of the upper structure 111, a space left open in front of the boom 114 when it is tilted up is increased. Therefore, when holding dug earth and sand, etc. in the bucket 122 and loading them on a dump track or the like by tilting up the boom 114, the earth and sand, etc. can be more easily loaded because of a larger spacing between the boom 114 and the dump track.

[0098] It is to be noted that the positional relationship between the horizontal pin 116A at the foot end of the boom cylinder 116 and the swing pin 130 is not limited to that shown in Fig. 16, but may be optionally set.

[0099] With this embodiment described above, since the coupling point between the boom 114 and the swing post 113 is positioned rearwardly of the swing center of the swing post 113 away from the front attachment 101, the minimum turn radius in the turning posture can be so reduced as to realize the ultra-small turn. Also, since the position of the swing post 113 is not changed, the same side ditch distance as in the prior art is ensured and, in the deep digging posture, the same maximum digging depth as in the prior art is obtained.

[0100] Further, since the maximum digging reach length is shortened, the tipping moment is reduced to increase stability of the excavator.

[0101] Additionally, when the front attachment 101 is directed forwardly, a wider space is left open in front of the boom 114. Therefore, when loading dug earth and sand, etc. on a dump track or the like from the bucket 122, the earth and sand, etc. can be more easily loaded because of the wider space left open in front of the boom.

[0102] Since the horizontal pin 131 is positioned rearwardly of the swing post 113 away from the front attachment 101, a front upper portion of the swing post 113 can be made smaller and hence the entire size of the swing post 113 itself can be reduced.

[0103] While the swing post 113 is disposed on the upper structure 111 in a central position forwardly of the cab 112 in the above embodiment, the present invention is not limited to such an arrangement. For example, the swing post may be disposed in a position forwardly and laterally of the cab, or in a space formed by cutting out a rightside corner forwardly of the cab. As another alternative, the swing post may be disposed laterally of the cab. In any case, similar advantages can be obtained by setting a position of the coupling point between the boom and the swing post in a like manner to that in the above embodiment.

Claims

1. A swing type excavator comprising an undercarriage (10; 110), an upper structure (11; 111) mounted on said undercarriage (10; 110) in a turnable manner, and a cab (12; 112) and a front attachment, including a bucket (22; 122), an arm (19; 119) and a boom (14, 17; 114), both mounted on said upper structure (11, 111), said upper structure (11; 111) being provided with a swing post (13; 113) which supports said boom (14, 17; 114) of said front attachment in such a manner as able to swing the whole of said front attachment horizontally, characterized in that a coupling point between said boom (14, 17; 114) and said swing post (13; 113) is positioned rearwardly of the swing center of said swing post (13; 113) away from said front attachment.
2. A swing type excavator according to claim 1, characterized in that said boom (114) is a mono-boom.
3. A swing type excavator according to claim 1, characterized in that said boom (14, 17) is a two-piece boom having a lower boom (14) vertically tiltable by a boom cylinder (16) with respect to said swing post (13) and an upper boom (17) vertically tiltable with respect to said lower boom (14).
4. A swing type excavator according to claim 1, characterized in that said front attachment includes opening angle adjustment means (15, 16) for changing a vertical opening angle between said lower boom (14) and said upper boom (17) depending on a vertical tilt angle of said lower boom (14), and that said swing post (13) is mounted on said upper structure through a swing pin (30) in a position forwardly and laterally of said cab (12) so that said lower boom (14) can be tilted rearwardly up to a position beyond a line laterally extending from a front part of said cab (12).
5. A swing type excavator according to claim 4, characterized in that said opening angle adjustment means comprises a cross link (15) having one end coupled to said swing post (13) through a horizontal pin (35) and the other end coupled to said upper boom (17) through a horizontal pin (34) such that said cross link (15) intersects a line connecting the coupling point between said lower boom (14) and said swing post (13) and a coupling point between said lower boom (14) and said upper boom (17).
6. A swing type excavator according to claim 4, characterized in that said opening angle adjustment means comprises a hydraulic cylinder (16) having one end coupled to said swing post (13) or said lower boom (14) through a horizontal pin (16A) and the other end coupled to said upper boom (17) through a horizontal pin (16B), and means for controlling extension and contraction of said hydraulic cylinder (16) such that the opening angle between said lower boom and said upper boom (17) is changed depending on the vertical tilt angle of said lower boom (14).

FIG.1

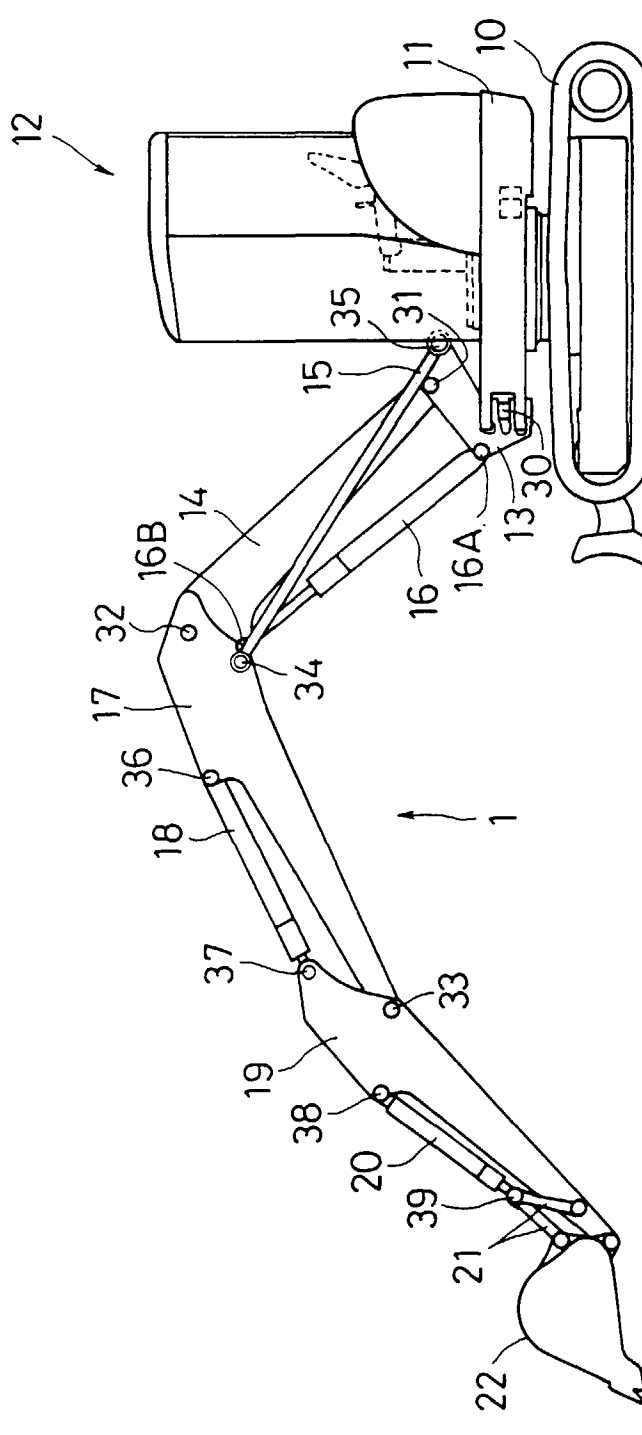


FIG.2

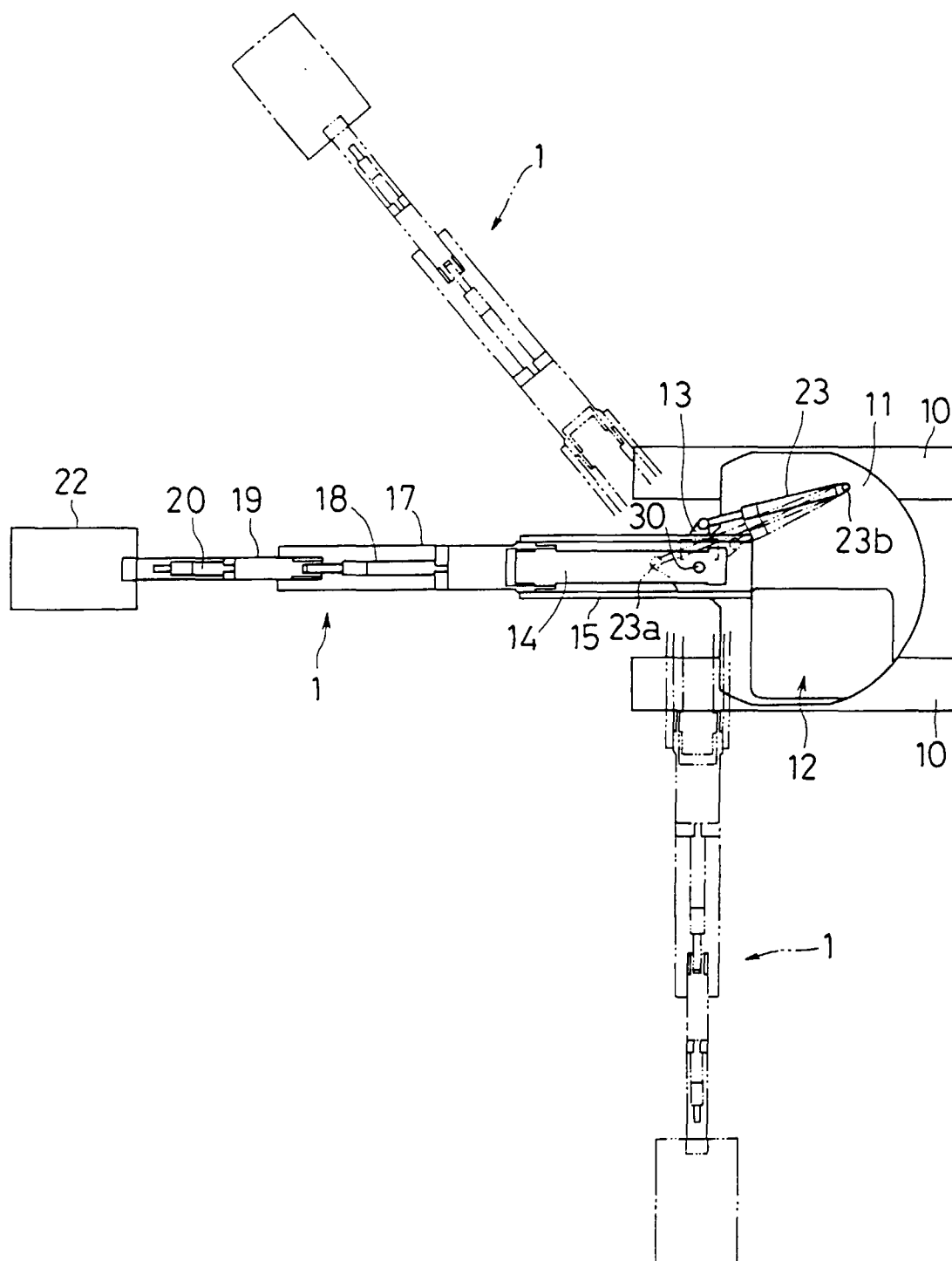


FIG.3

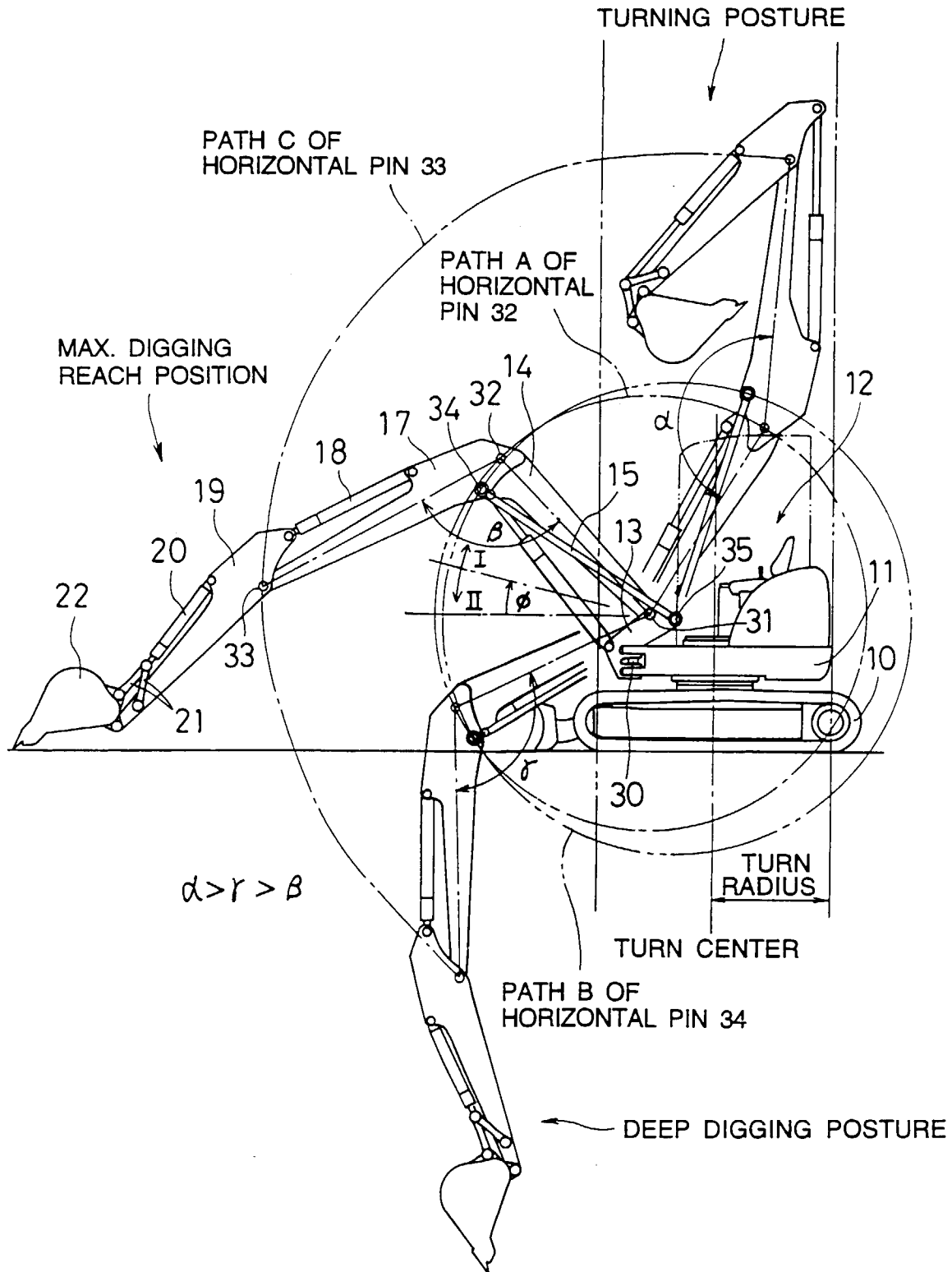


FIG.4

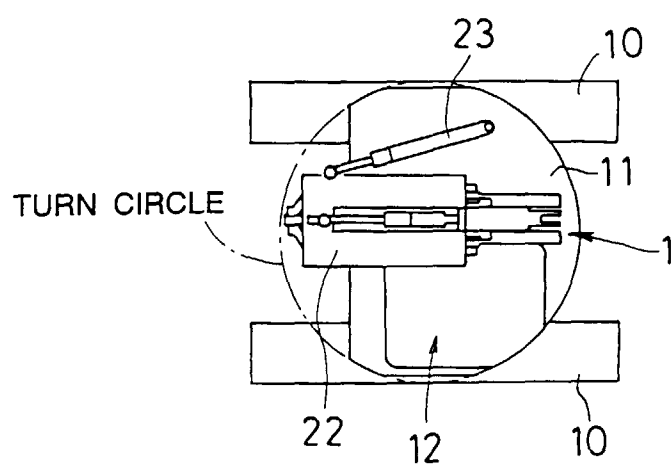


FIG.5A

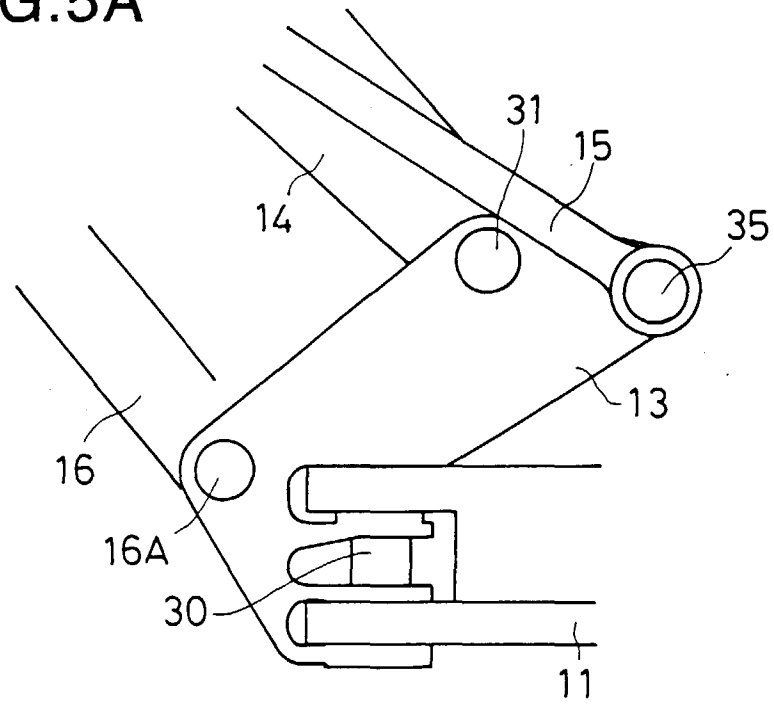
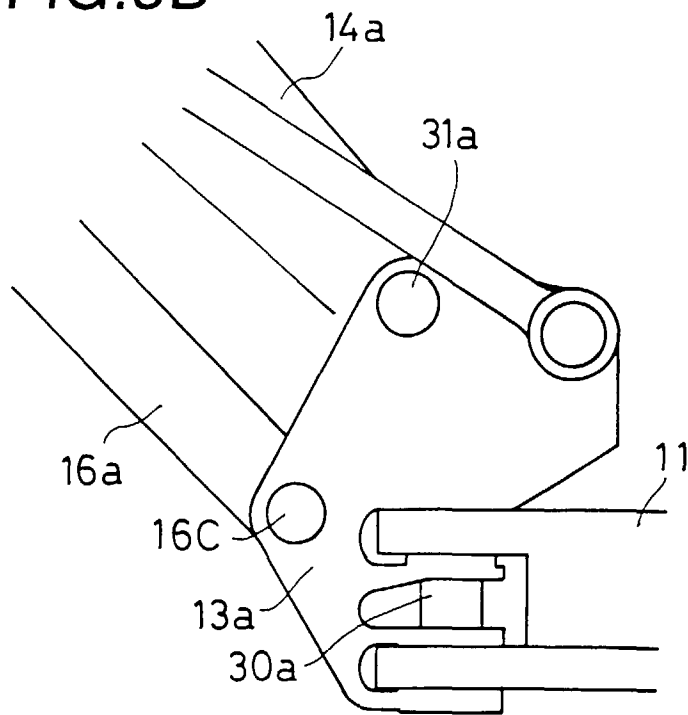


FIG.5B



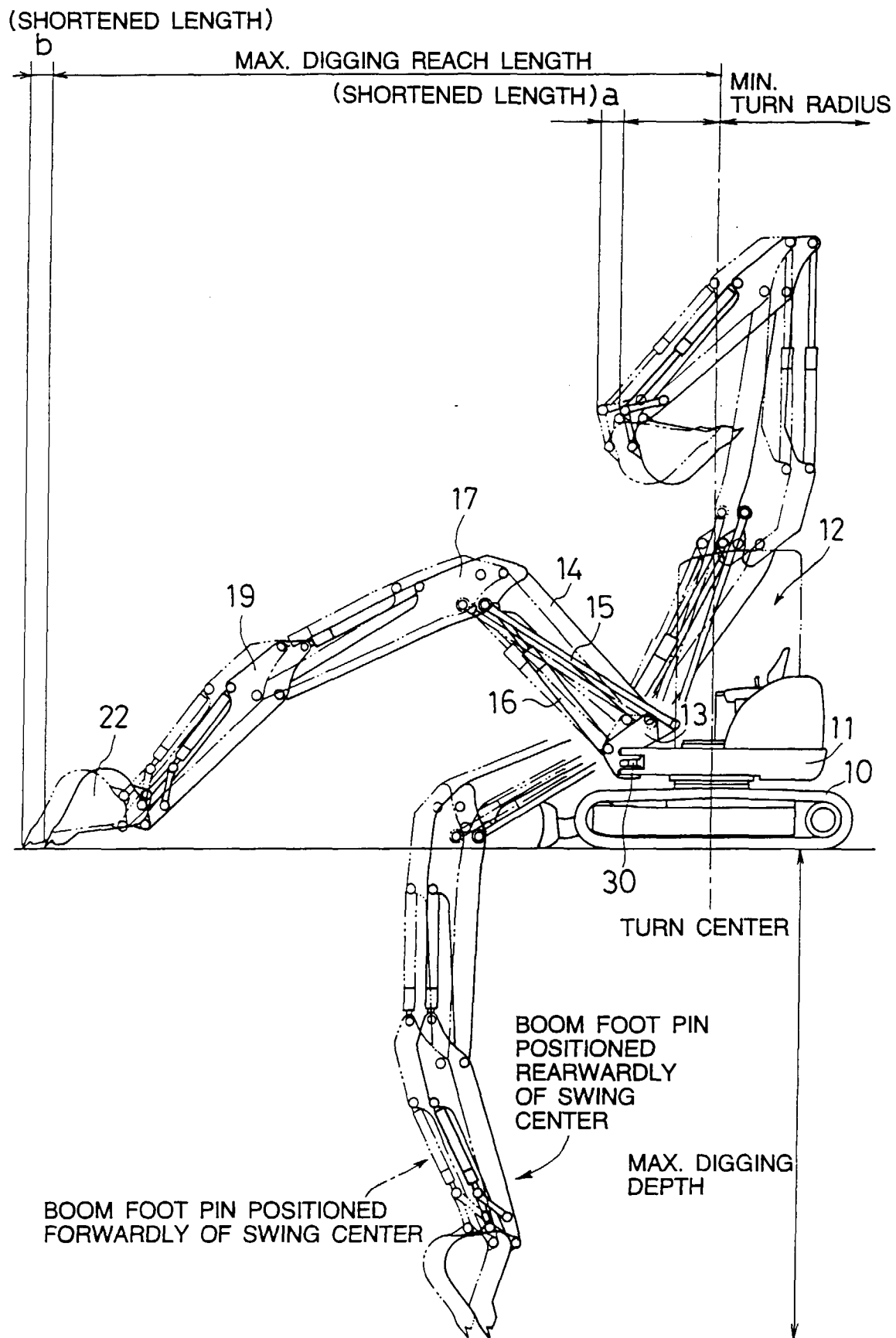


FIG.7A

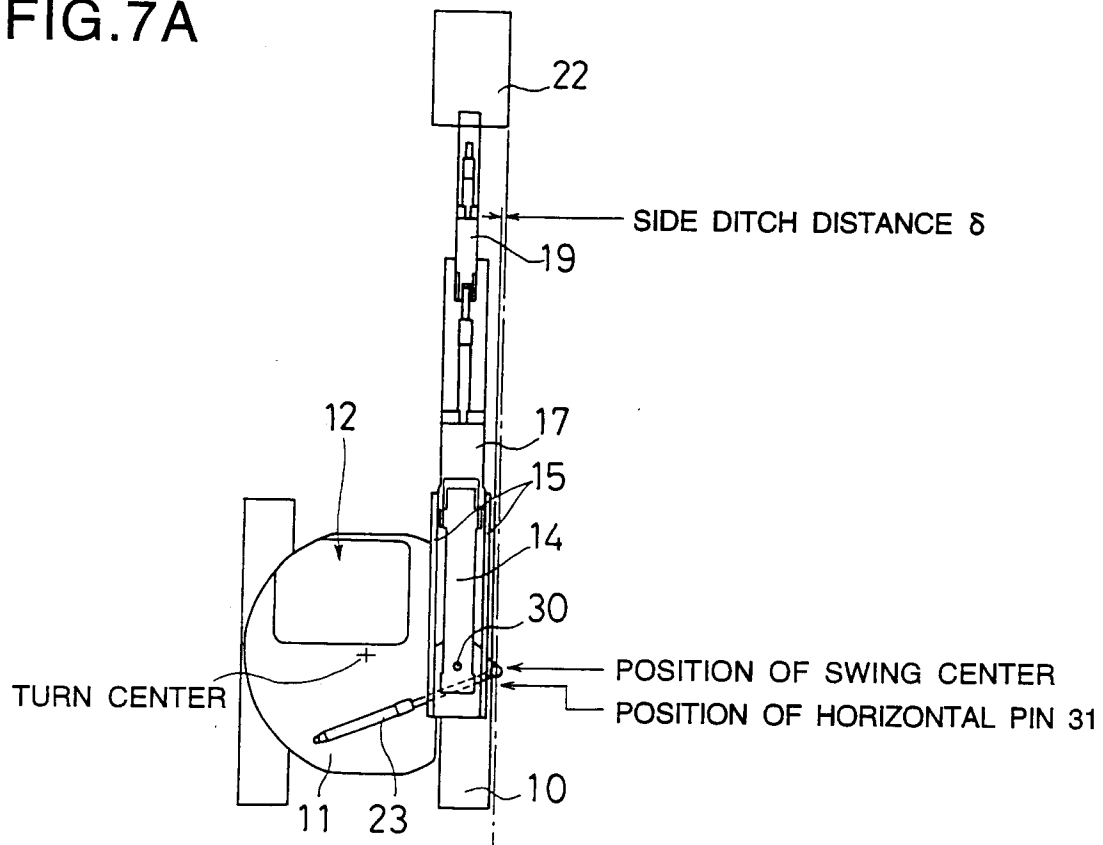


FIG.7B

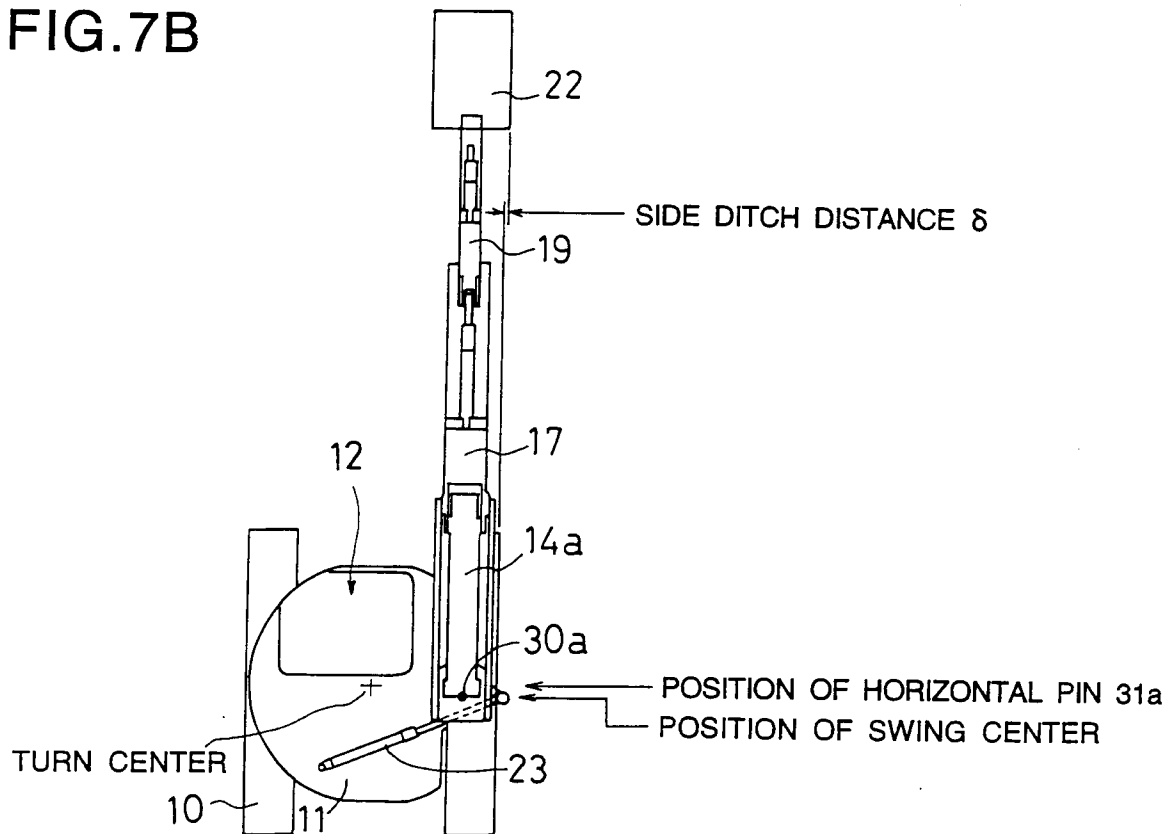


FIG.8

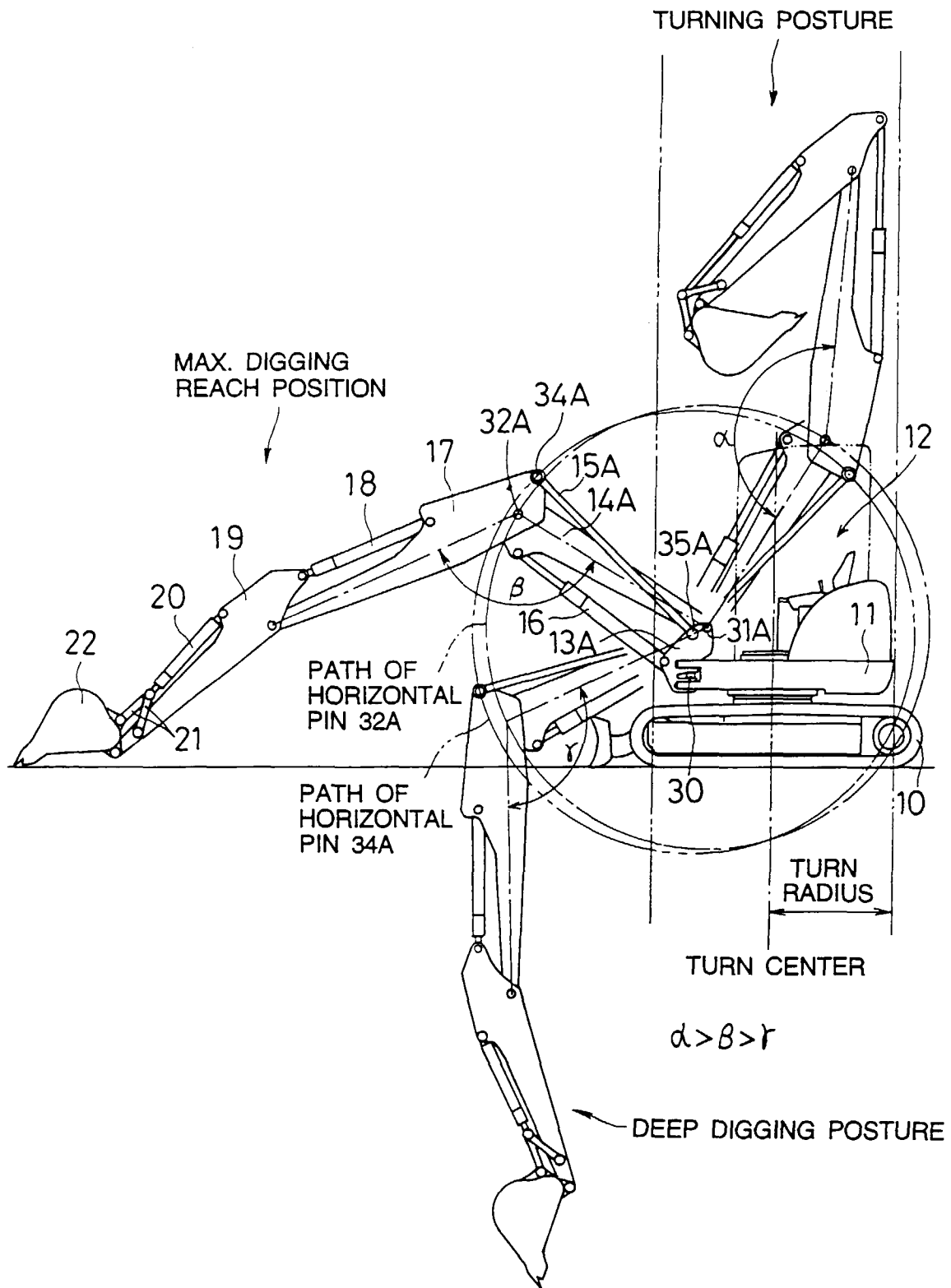


FIG.9

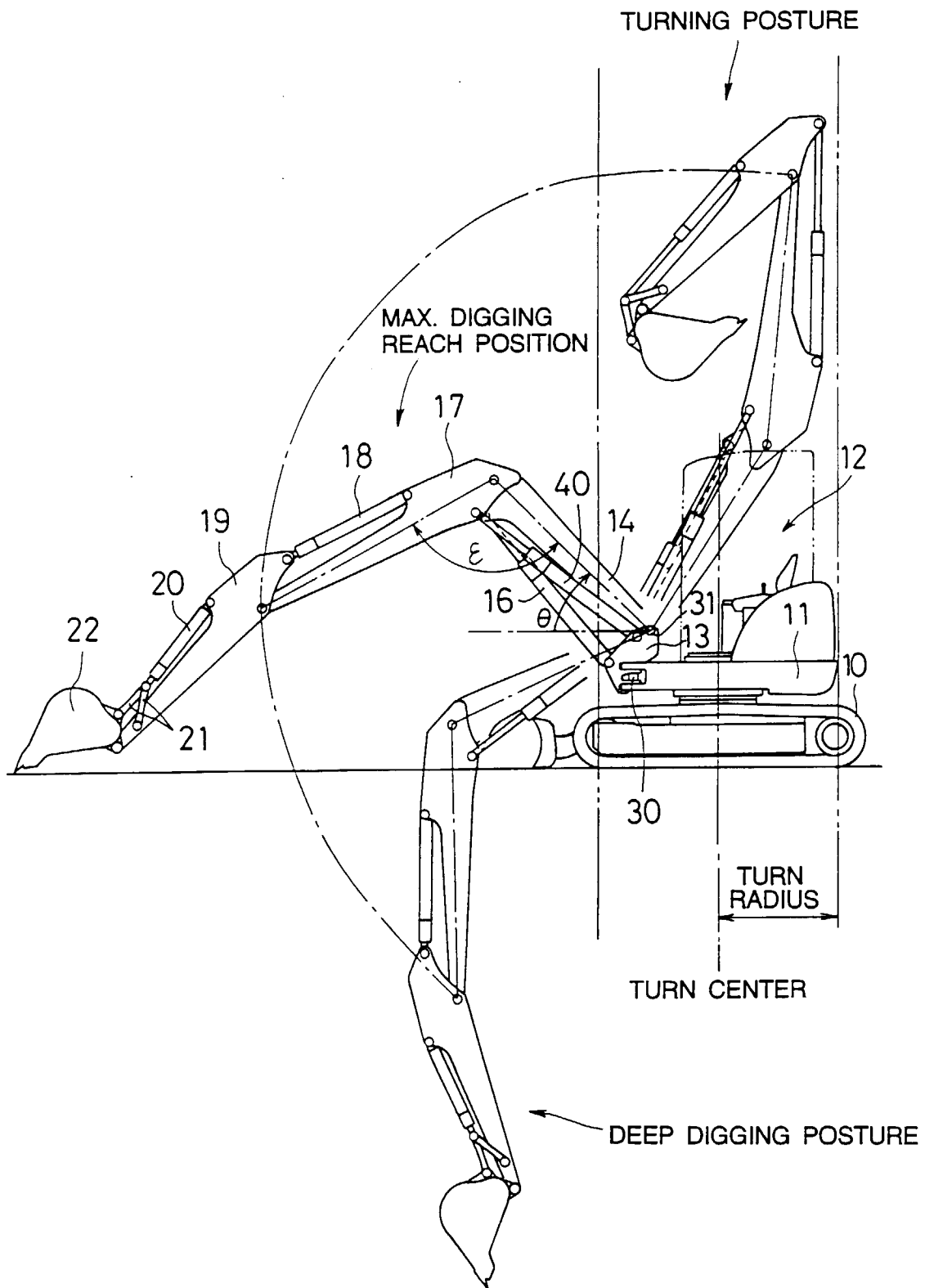


FIG.10

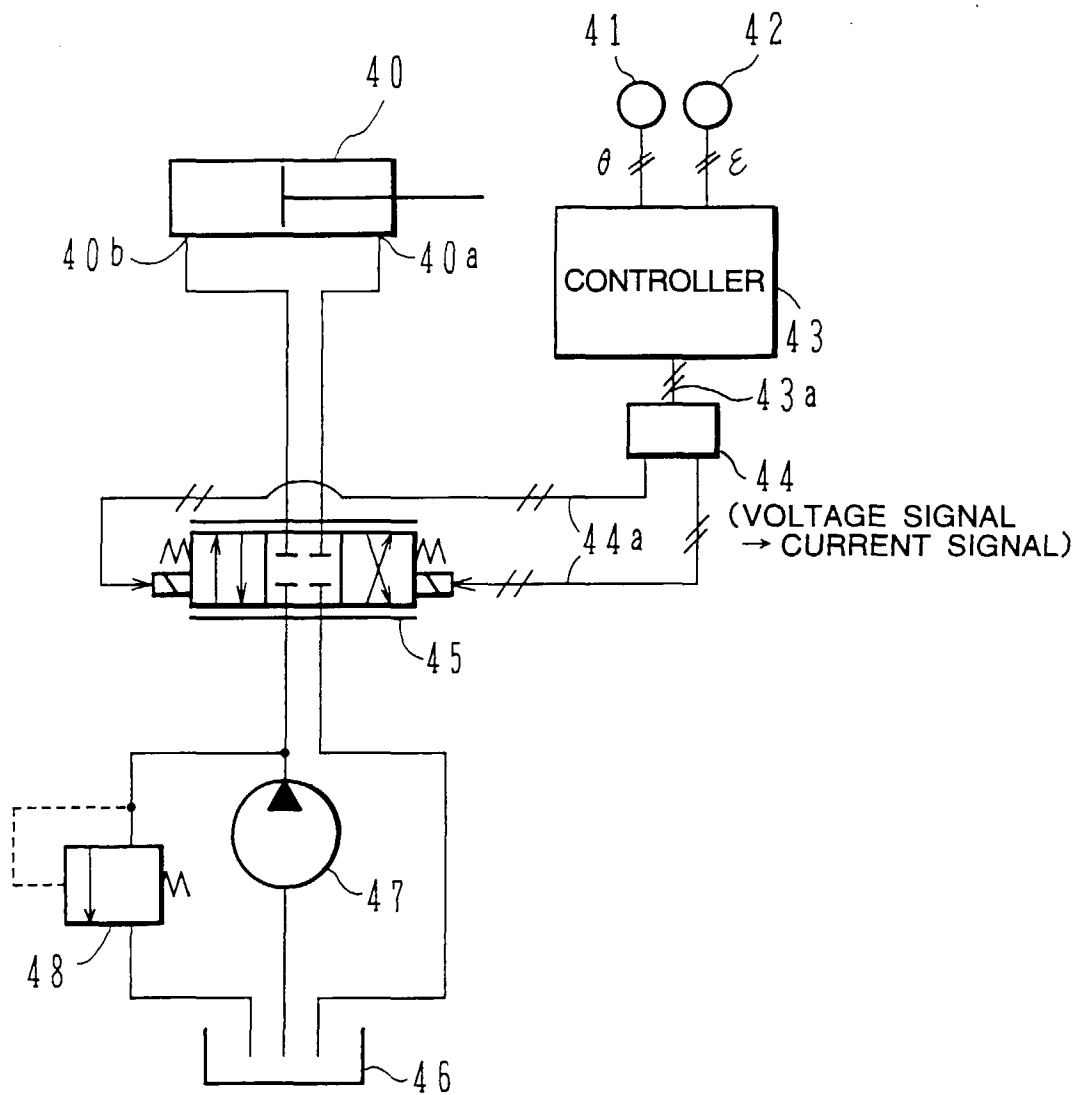


FIG.11

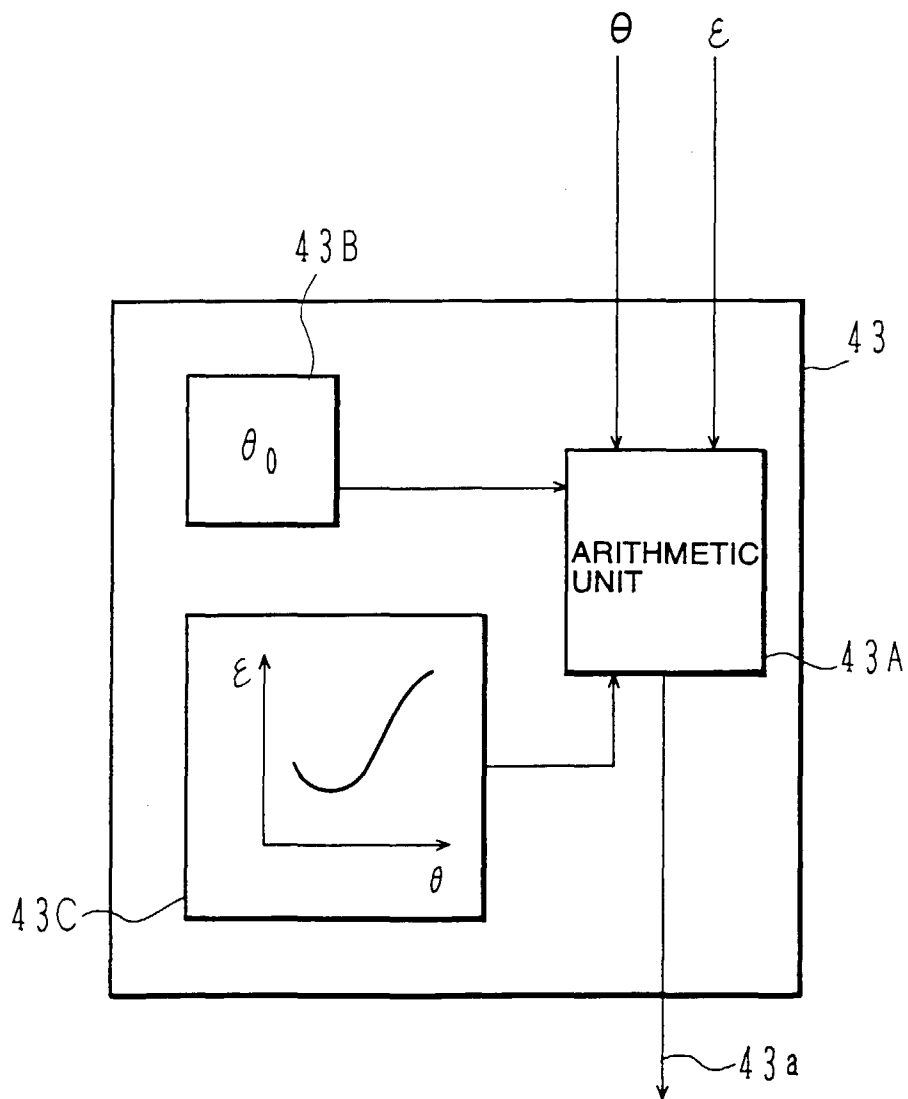


FIG.12

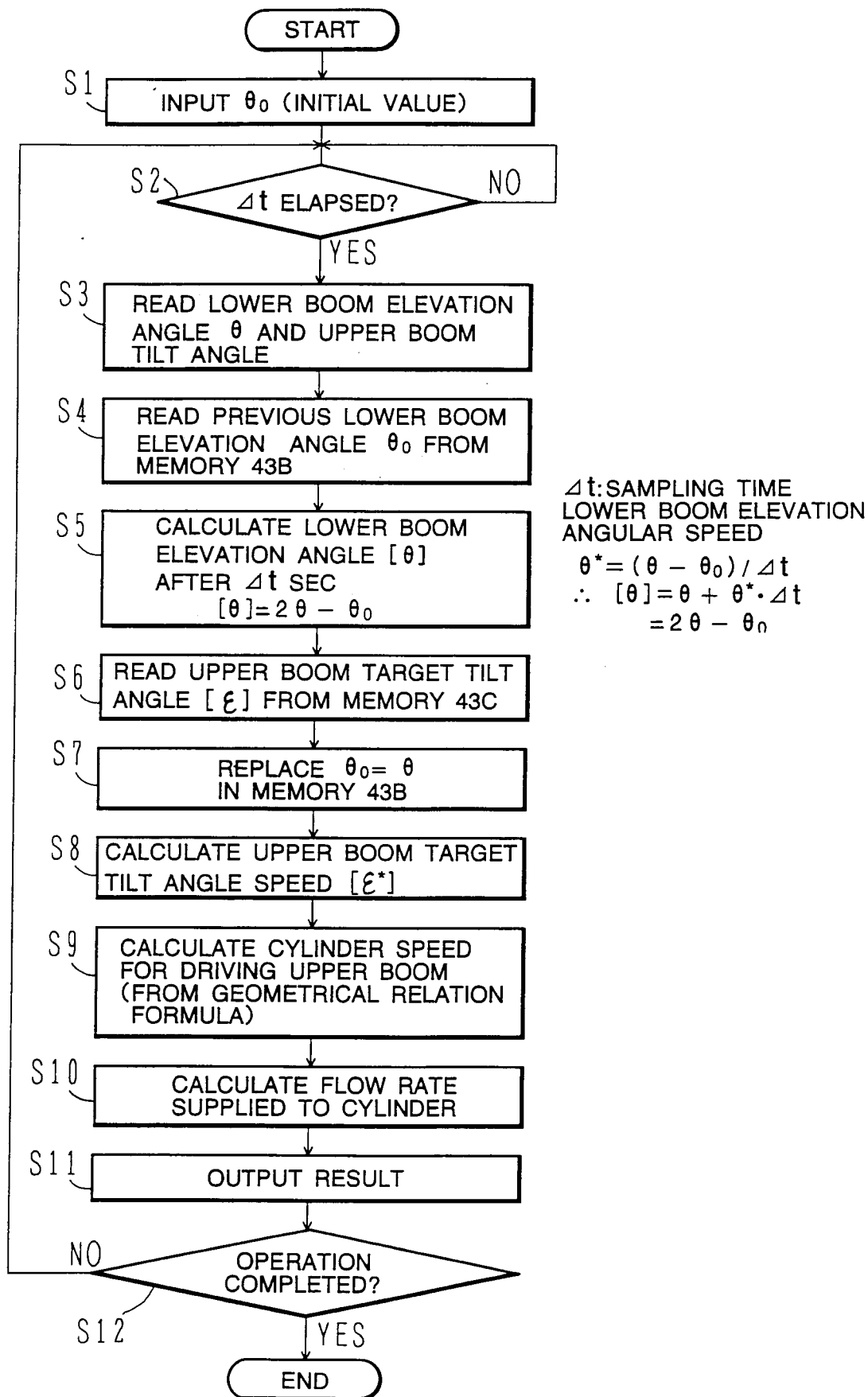


FIG.13

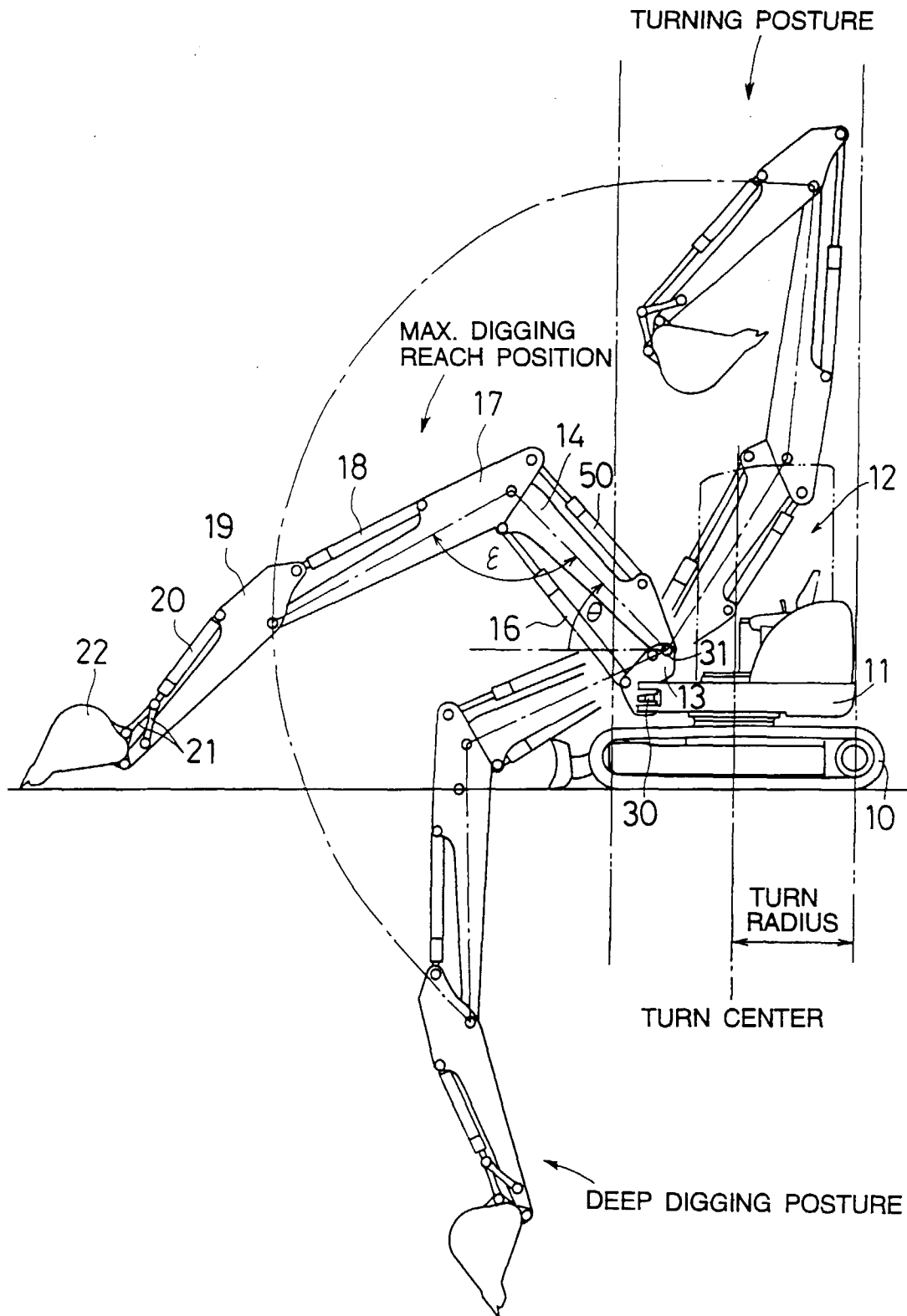


FIG.14

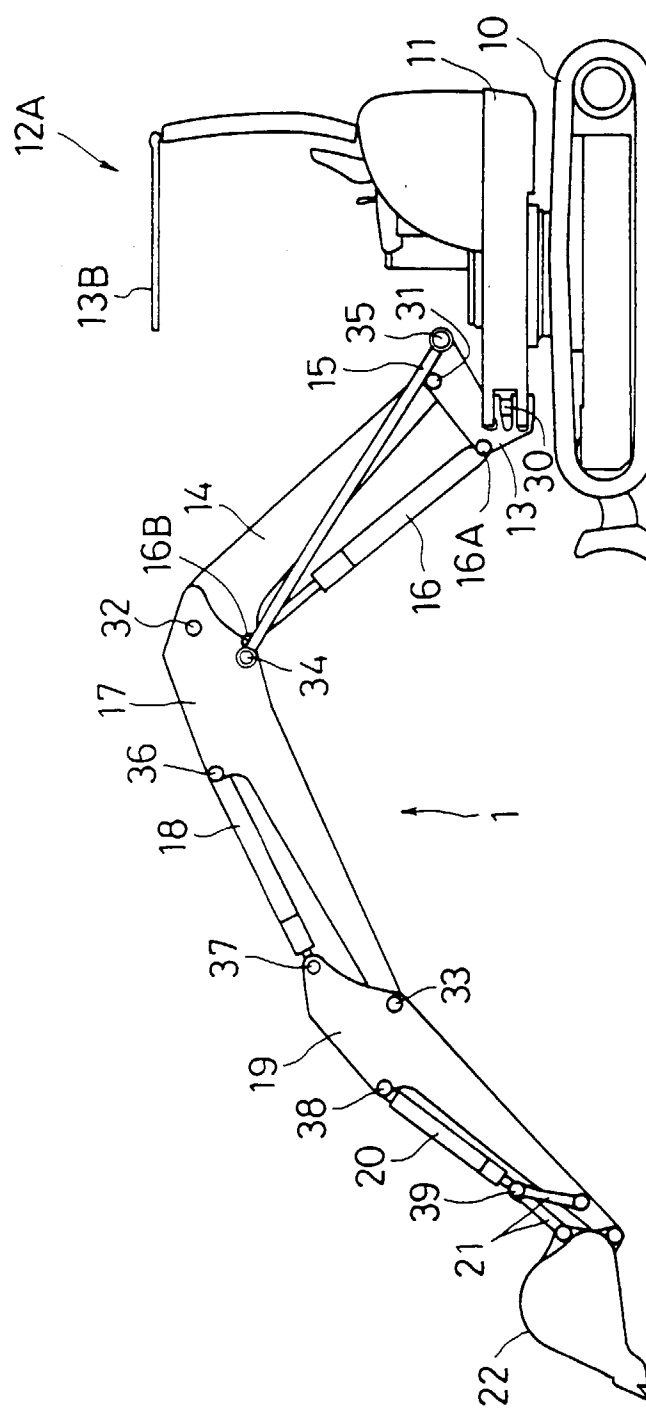


FIG. 15

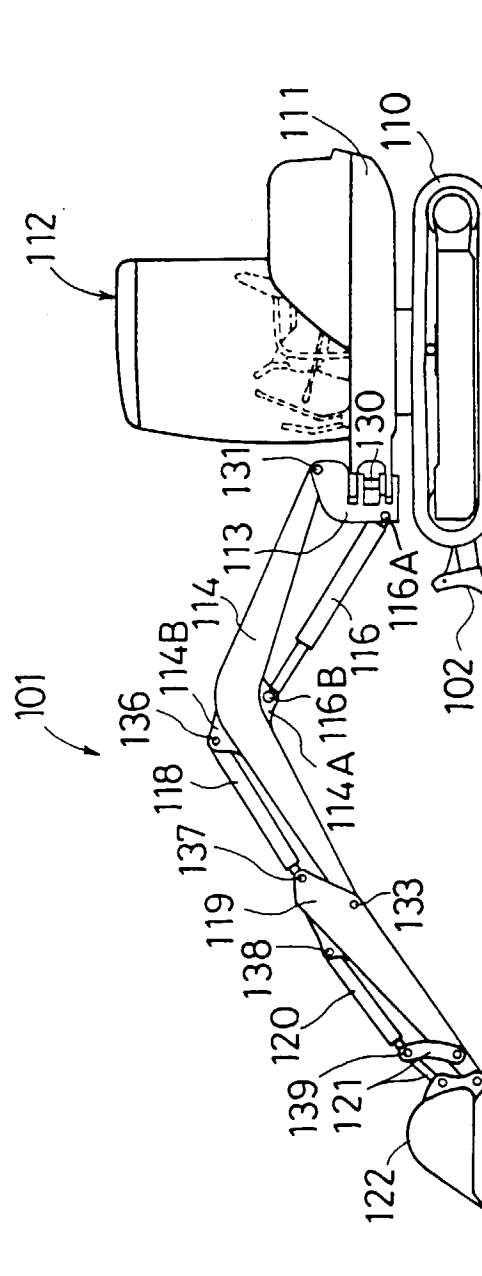


FIG.16A

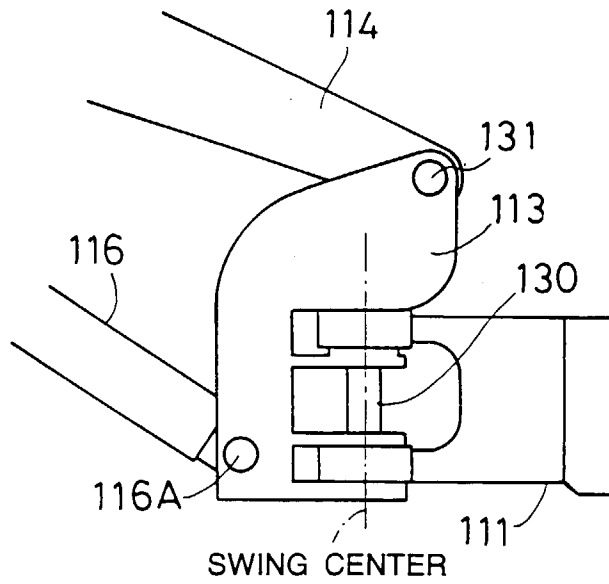


FIG.16B

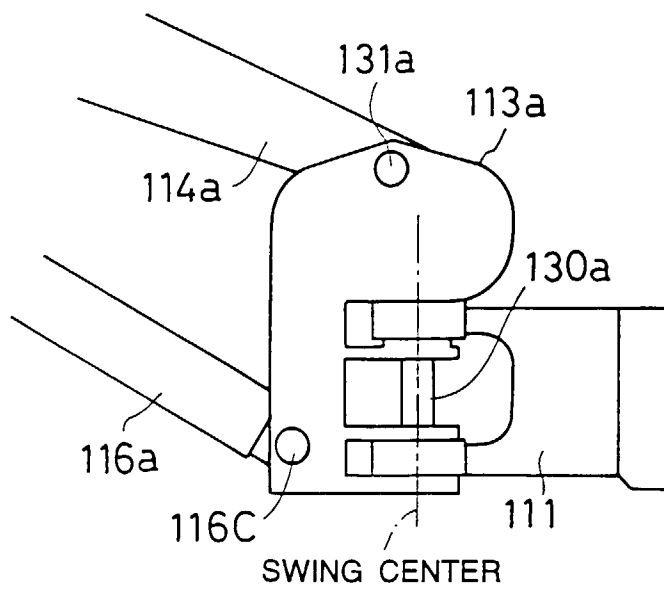


FIG.17

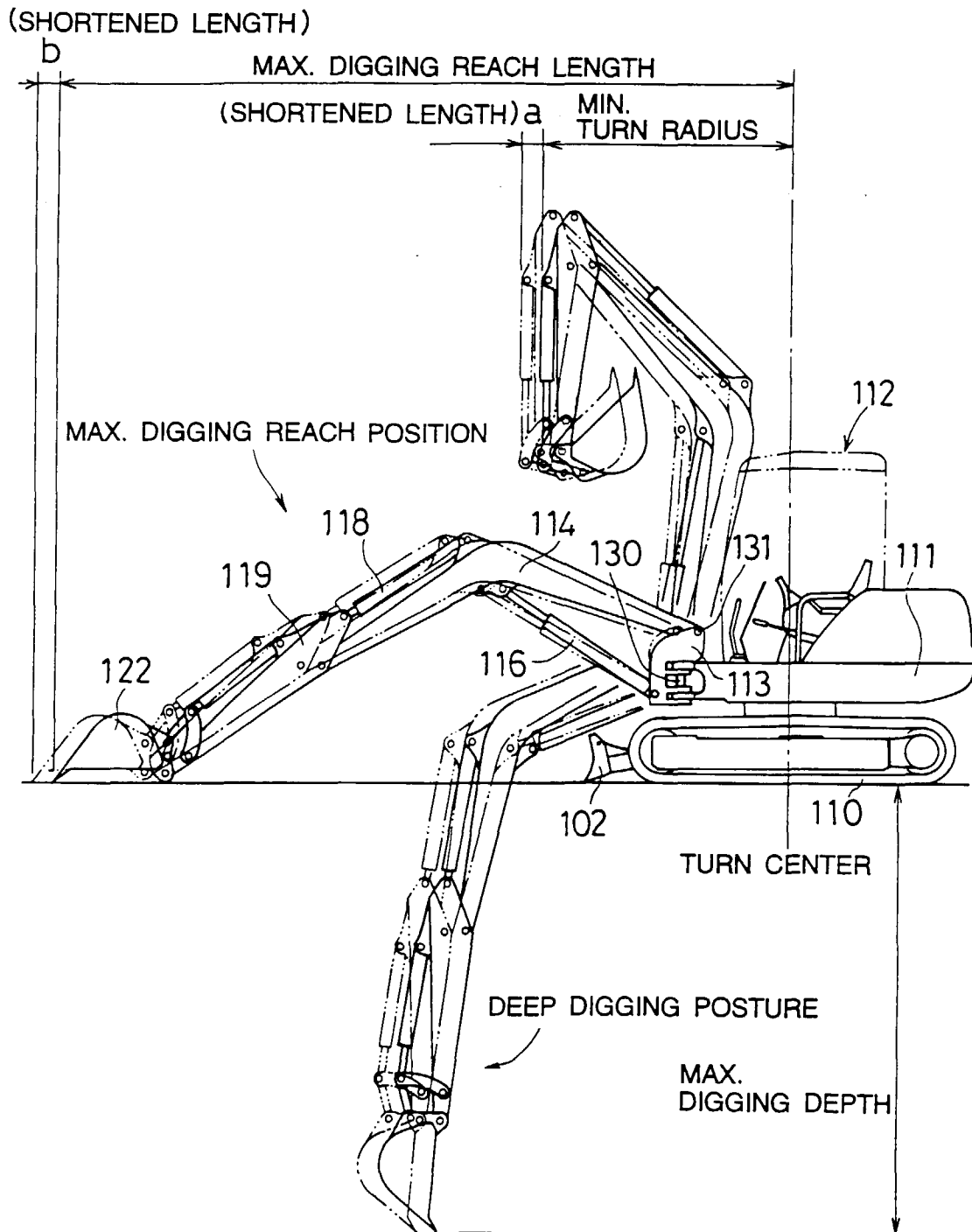


FIG.18A

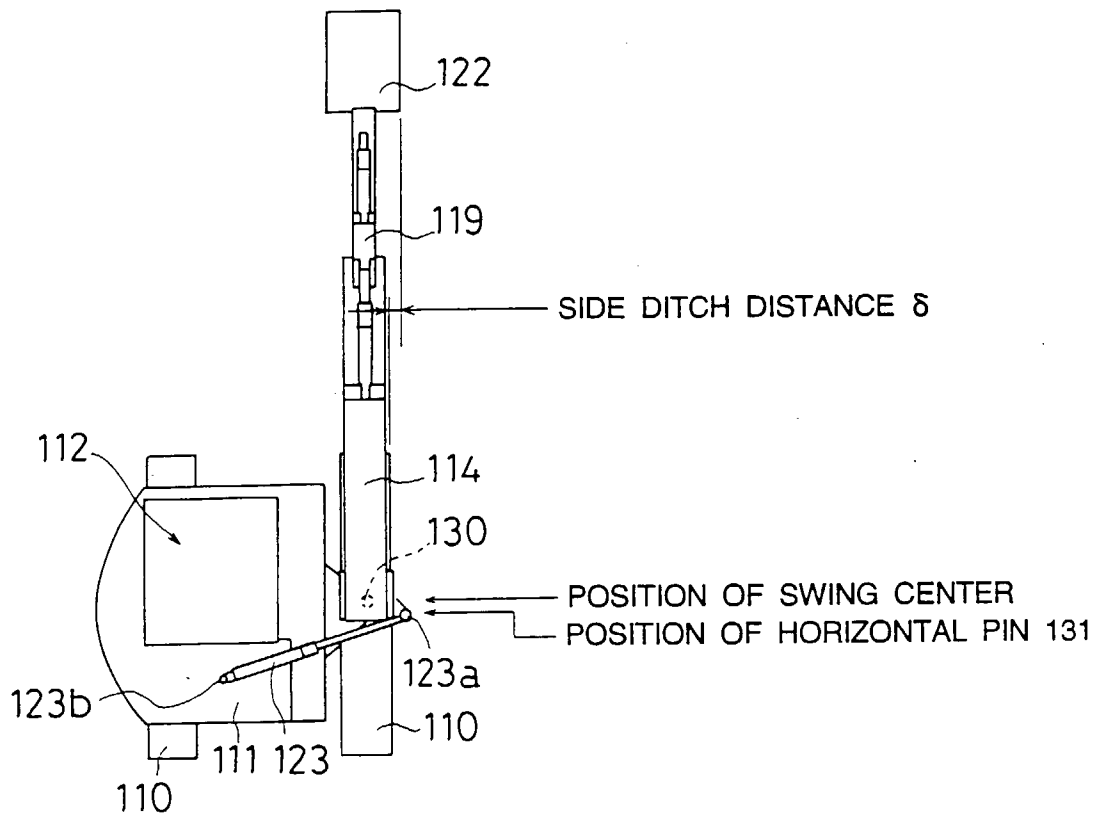


FIG.18B

