

## SPECIFICATION

MULTISTAGE TELESCOPIC ARM DEVICE AND DEEP DIGGING EXCAVATOR WITH  
THE SAME

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### TECHNICAL FIELD

[0001] The present invention relates to a multistage telescopic  
arm device and a deep digging excavator with the multistage  
telescopic arm device that are used suitably for work of deeply  
10 excavating the ground in a civil engineering work, for example.

### BACKGROUND ART

[0002] In general, a deep digging excavator is used suitably in  
a case of deeply excavating a vertical shaft in the ground in  
15 a civil engineering work. The deep digging excavator includes  
an automotive vehicle body, a boom liftably provided on the  
vehicle body, and a multistage telescopic arm device provided  
in a distal end side of the boom. The multistage telescopic arm  
device includes a telescopic arm that has an outer tube extend  
20 in the upper-lower direction and multistage inner tubes, an arm  
extension fixed sheave that is fixedly provided on the outer tube,  
a telescopic cylinder that is arranged along the outer tube in  
the length direction, a sheave mounting member that is mounted  
on the telescopic cylinder and moves in the length direction of  
25 the outer tube, an arm extension movable sheave that is mounted  
on the sheave mounting member, and an arm extension rope one end  
side of which is fixed to the outer tube, the other end side of  
which is fixed to the inner tube, and the midway section of which

is wound around the arm extension fixed sheave and the arm extension movable sheave. Further, a clamshell bucket for earth and sand excavation is attached on a distal end of the inner tube.

[0003] In the deep digging excavator according to this conventional art, the inner tube of the telescopic arm extends downward from the outer tube by contracting the telescopic cylinder provided in the distal end side of the boom in a state of holding the telescopic arm vertically to the ground.

Accordingly, the excavator can perform the excavation of earth and sand using the clamshell bucket attached to the distal end part (lower end part) of the inner tube.

[0004] After having grasped the earth and sand excavated by the clamshell bucket, the telescopic cylinder is extended, and thereby, the inner tube is pulled up together with the clamshell bucket into the outer tube by the arm extension rope. In this state, an upper revolving structure in the excavator is revolved toward a predetermined earth and sand discharging position and the clamshell bucket is opened, thus making it possible to discharge the earth and sand excavated (See, Patent Document 1).

#### PRIOR ART DOCUMENT

#### PATENT DOCUMENT

[0005] Patent Document 1: Japanese Patent Laid-Open No. S62-82131

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#### SUMMARY OF THE INVENTION

[0006] Incidentally, in the deep digging excavator by the aforementioned conventional art, a tube of the telescopic

cylinder is attached on the outer tube of the telescopic arm, and a rod of the telescopic cylinder projects downward from the tube. Therefore, a sheave mounting member (hanger) that supports the arm extension movable sheave is mounted on a lower end of the rod.

[0007] Therefore, in the deep digging excavator by the conventional art, at the time of pulling up the clamshell bucket, the rod of the telescopic cylinder is extended downward to move the sheave mounting member downward. Thereby, the arm extension rope is reeled between the arm extension movable sheave supported by the sheave mounting member and the arm extension fixed sheave fixed on the outer tube to be able to pull up the inner tube into the outer tube.

[0008] However, in the deep digging excavator by the conventional art, the tube of the telescopic cylinder is attached on the outer tube. Therefore, by extending the rod downward from the tube of the telescopic cylinder, the sheave mounting member is moved downward to reel the arm extension rope between the arm extension movable sheave and the arm extension fixed sheave and pull up the clamshell bucket. Accordingly, in the conventional art, at the time of pulling up the clamshell bucket, the weight of the sheave mounting member is loaded on the arm extension rope, but the weight of the tube of the telescopic cylinder is not loaded on the arm extension rope. In this way, the deep digging excavator by the conventional art has a problem that at the time of pulling up the inner tube into the outer tube together with the earth and sand excavated by the clamshell bucket, the weight of the tube of the telescopic cylinder cannot be utilized as a

pulling-up force and therefore, a pulling-up operation of the inner tube by the telescopic cylinder cannot be efficiently performed.

[0009] The present invention is made in view of the above-mentioned problem in the conventional art, and an object of the present invention is to provide a multistage telescopic arm device and a deep digging excavator with the multistage telescopic arm device that are configured to be able to increase a pulling-up force of an inner tube by using the weight of a tube of an telescopic cylinder at the time of extending the telescopic cylinder to pull up the inner tube.

[0010] (1) The present invention is applied to a multistage telescopic arm device comprising: a telescopic arm that is provided on a distal end side of a boom of a mount target to be extendible in the upper-lower direction and includes an outer tube and multistage inner tubes accommodated inside of the outer tube to be extensible in the length direction; a telescopic cylinder that is provided along the length direction of the outer tube configuring part of the telescopic arm; arm extension fixed sheaves that are fixedly provided on the outer tube; a sheave mounting member that is mounted on the telescopic cylinder and moves in the length direction of the outer tube in such a manner as to come close to or be away from the arm extension fixed sheaves; arm extension movable sheaves that are provided on the sheave mounting member; and arm extension ropes one end side of each of which is fixed to the outer tube, the other end side of each of which is fixed to an innermost inner tube of the inner tubes, and a midway section of each of which is wound around each of

the arm extension fixed sheaves and each of the arm extension movable sheaves.

[0011] The configuration adopted by the present invention is characterized in that the telescopic cylinder is configured of a hydraulic cylinder comprising a tube, and a rod one side of which is fixed to a piston in the tube and the other side of which projects outside from the tube, a distal end part of the rod is attached to the outer tube of the telescopic arm in a state where the rod of the telescopic cylinder faces upward and the tube of the telescopic cylinder is formed as a free end, and the sheave mounting member is mounted to the tube of the telescopic cylinder.

[0012] With this arrangement, in a case of pulling down the inner tube on which the excavating member is mounted, the telescopic cylinder is contracted by pulling in the rod into the tube of the telescopic cylinder. In this state, the arm extension movable sheave supported to the sheave mounting member move upward to approach the arm extension fixed sheave fixed to the outer tube. Therefore, the arm extension rope wound around the arm extension fixed sheave and the arm extension movable sheave is reeled out, thus making it possible to extend the inner tube to which the other end side of the arm extension rope is fixed outside of the outer tube. On the other hand, in a case of pulling up the inner tube on which the excavating member is mounted, the telescopic cylinder is extended by causing the rod to project out of the tube. In this state, the arm extension movable sheave supported to the sheave mounting member moves downward to be away from the arm extension fixed sheave fixed to the outer tube. Therefore, the arm extension rope is reeled between the arm

extension fixed sheave and the arm extension movable sheave to pull in the inner tube to which the other end side of the arm extension rope is fixed inside of the outer tube, thus making it possible to contract the telescopic arm.

5 [0013] In this case, the rod of the telescopic cylinder is directed upward, and the distal end part of the rod is attached on the outer tube. Therefore, at the time of extending the telescopic cylinder, the tube as a heavy load and the sheave mounting member together move downward, and the inner tube is pulled up inside  
10 of the outer tube through the arm extension rope wound around the arm extension movable sheave and the arm extension fixed sheave. In this case, downward loads by the weight of the tube and the sheave mounting member act on the tube moving downward. Therefore, the pulling-up force of the inner tube can be increased  
15 by using the weight of the tube and the sheave mounting member to efficiently perform the pulling-up operation of the inner tube by the telescopic cylinder.

[0014] (2) According to the present invention, the distal end part of the rod in the telescopic cylinder is attached to an upper  
20 part side of the outer tube.

[0015] Accordingly, it is possible to move the tube of the telescopic cylinder, to which the sheave mounting member is mounted, in the upper-lower direction within a range of a nearly upper half of the outer tube extending in the upper-lower  
25 direction. Therefore, for example, even in a case where a lower half of the outer tube goes into the ground at the time of excavating the vertical shaft, since an operator in the vehicle body side on which the boom is provided can visually confirm a

telescopic motion of the telescopic cylinder and the like, it is possible to enhance workability and safety of the excavating work.

[0016] (3) According to the present invention, a sheave mounting member guide rail is provided outside of the outer tube, the sheave mounting member guide rail being mounted on the outer tube to extend in the length direction in parallel to the outer tube, and the sheave mounting member moves along the sheave mounting member guide rail in response to extension and contraction of the telescopic cylinder.

[0017] With this arrangement, when the telescopic cylinder moves the sheave mounting member, the sheave mounting member can move all the time on a constant track by guidance of the sheave mounting member guide rail. As a result, the arm extension rope wound around the arm extension fixed sheave and the arm extension movable sheave can smoothly follow up the movement of the arm extension movable sheave supported to the sheave mounting member to enhance the safety of the telescopic motion of the inner tube to the outer tube. In addition, since strength of the outer tube can be increased by the sheave mounting member guide rail provided to the outer tube, reliability of the entire telescopic arm can be enhanced.

[0018] On the other hand, the tube to which the sheave mounting member is mounted can also move on a constant track along the sheave mounting member guide rail. As a result, the strength of the telescopic cylinder against buckling and lateral loads acting thereon can be increased to enhance the reliability of the telescopic cylinder.

[0019] (4) According to the present invention, a pair of boom brackets are provided outside of the outer tube and in a lower section of the outer tube than the sheave mounting member, the pair of boom brackets facing with each other with an interval in the left-right direction and being mounted to the distal end side of the boom to be able to be rocked thereto, and the tube of the telescopic cylinder is arranged in a gap formed between the pair of boom brackets.

[0020] With this arrangement, since the telescopic cylinder is arranged in the gap formed between the pair of boom brackets provided outside of the outer tube, the telescopic cylinder, the sheave mounting member mounted to the tube of the telescopic cylinder, the arm extension movable sheave supported to the sheave mounting member, the arm extension rope wound around the arm extension fixed sheave and the arm extension movable sheave, and the like can be visualized from the vehicle body side to which the boom is provided. Therefore, the operator in the vehicle body side can accurately perform an operation of extending or contracting the inner tube to the outer tube while directly visualizing the telescopic cylinder and the like.

[0021] On the other hand, it is not necessary to provide the telescopic cylinder, the arm extension fixed sheave, the sheave mounting member, the arm extension movable sheave and the like on a side surface of the outer tube at the opposite to the surface of the outer tube on which the boom bracket is provided, that is, the side surface at the opposite to the vehicle body. Therefore, at the time of excavating the vertical shaft or the like, the telescopic cylinder and the like do not come in contact

with obstacles to be damaged, thus making it possible to enhance workability of the excavating work.

[0022] In addition, in a case of placing the outer tube on the ground for putting the multistage telescopic arm device in the transport posture, the surface at the opposite to the surface mounted to the boom can be placed on the ground. Thereby, at the time of placing the outer tube on the ground, the telescopic cylinder, the sheave mounting member, the arm extension fixed sheave, the arm extension movable sheave and the like can be held in an upward posture where the weight of the telescopic arm does not act, without using a particular platform or the like.

[0023] Accordingly, in a state where the multistage telescopic arm device is placed in the transport posture, since a maintenance work to the telescopic cylinder provided on the outer tube, the arm extension fixed sheave, the sheave mounting member, the arm extension movable sheave and the like can be performed in a position close to the ground, it is possible to enhance the workability of the maintenance work therefor.

[0024] (5) According to the present invention, a tube guide is provided outside of the outer tube to movably accommodate the tube of the telescopic cylinder and guide the tube in the length direction of the outer tube.

[0025] With this arrangement, the tube to which the sheave mounting member is mounted can be smoothly moved by guiding a free end side of the tube in the telescopic cylinder in the length direction of the outer tube by the tube guide. Therefore, the tube of the telescopic cylinder can smoothly move on a constant track along the tube guide to increase the strength of the

telescopic cylinder to buckling or lateral loads acting thereon. Further, by accommodating the tube into the tube guide, the tube can be protected from falling rocks and the like at the excavating.

[0026] (6) According to the present invention, the outer tube is formed in an angular tube shape having a cross-section configuration of a polygonal shape including at least a rear surface attached to a distal end side of the boom, a front surface facing the rear surface in the front-rear direction, a left side surface and a right side surface that are opposed to each other in the left-right direction having the rear surface and the front surface therebetween, a left inclined surface arranged to be obliquely inclined between the rear surface and the left side surface, and a right inclined surface arranged to be obliquely inclined between the rear surface and the right side surface, and the arm extension movable sheaves are arranged closer to the outside in the left-right direction than the left and right side surfaces configuring part of the outer tube.

[0027] With this arrangement, the outer tube is formed in the tubular shape having the cross-section configuration of the polygonal shape, and the left and right inclined surfaces are provided between the rear surface attached to the distal end side of the boom and the left and right side surfaces. Therefore, it is possible to increase the buckling strength of the telescopic cylinder to the load acting on the outer tube. Thereby, the lifetime of the outer tube can be extended to enhance the reliability of the telescopic arm.

[0028] In addition, the arm extension movable sheave supported to the sheave mounting member is arranged closer to the outside

in the left-right direction than each of the left and right side surfaces configuring part of the outer tube. Therefore, it is possible to suppress the arm extension movable sheave from largely projecting in the rear surface side of the outer tube. As a result, even in a case of using the arm extension movable sheave of a sheave having a large diameter, since the periphery of the arm extension movable sheave can be miniaturized, the lifetime of the arm extension rope can be extended by using the arm extension movable sheave provided with the sheave having the large diameter.

[0029] In this way, since the multistage telescopic arm device has the structure of being able to extend the lifetime of the arm extension movable sheave, it is possible to set loads acting on the arm extension rope to be large. As a result, the volume of the clamshell bucket mounted on the inner tube connected to the arm extension rope can be increased to excavate a large number of earth and sand.

[0030] (7) According to the present invention, the outer tube is formed in an angular tube shape having a cross-section configuration of a hexagonal shape including a rear surface attached to a distal end side of the boom, a front surface facing the rear surface in the front-rear direction, a left side surface and a right side surface that are opposed to each other in the left-right direction having the rear surface and the front surface therebetween, a left inclined surface arranged to be obliquely inclined between the rear surface and the left side surface, and a right inclined surface arranged to be obliquely inclined between the rear surface and the right side surface. Therefore, the buckling strength of the outer tube to loads acting thereon can

be increased to extend the lifetime of the outer tube.

[0031] (8) According to the present invention, pushing mechanisms are provided between the outer tube and a first-stage inner tube positioned in the outermost side among the multistage inner tubes, the pushing mechanisms pushing in the first-stage inner tube in the extension direction at the time of extending the first-stage inner tube from the outer tube by the telescopic cylinder, the pushing mechanisms respectively includes: pushing fixed sheaves provided in the outer tube to be positioned in a lower part side of the outer tube; pushing movable sheaves provided in the sheave mounting member in a lower position than the arm extension movable sheaves; and pushing ropes one end side of each of which is fixed to the outer tube, the other end side of each of which is fixed to the first-stage inner tube through an inside of the outer tube, and a midway section of each of which is wound around each of the pushing fixed sheaves and each of the pushing movable sheaves, sheave mounting openings are provided in the lower part side of the outer tube and in positions where the pushing fixed sheaves are provided, and a part of each of the pushing fixed sheaves is arranged inside of the outer tube through each of the sheave mounting openings.

[0032] With this arrangement, even in a case of setting the diameter of the pushing fixed sheave to be large, the pushing fixed sheave can be mounted to the outer tube in a compact manner. Accordingly, the pushing fixed sheave of a sheave having a large diameter may be used to extend the lifetime of the pushing rope.

[0033] In addition, as compared with the configuration of arranging the pushing fixed sheave in the lower end part of the

outer tube as the conventional art, the projecting amount of the lower end part of the first-stage inner tube projecting from the lower end part of the outer tube can be made smaller at the time of accommodating the first-stage inner tube into the outer tube.

5 As a result, an entire length of the telescopic arm at the time of contracting the telescopic arm at the maximum can be shortened. For example, at the time of transporting the deep digging excavator, a compact transport posture thereof can be made.

[0034] (9) The present invention is applied to a deep digging  
10 excavator including an automotive vehicle body, a boom liftably provided on the vehicle body, and a multistage telescopic arm device provided in a distal end side of the boom, wherein the multistage telescopic arm device comprising: a telescopic arm that includes an outer tube extending in the upper-lower direction  
15 and multistage inner tubes accommodated inside of the outer tube to be extensible in the length direction; a telescopic cylinder that is arranged along the length direction of the outer tube configuring part of the telescopic arm; arm extension fixed sheaves that are fixedly provided on the outer tube; a sheave  
20 mounting member that is mounted on the telescopic cylinder and moves in the length direction of the outer tube in such a manner as to come close to or be away from the arm extension fixed sheaves; arm extension movable sheaves that are provided on the sheave mounting member; and arm extension ropes one end side of each  
25 of which is fixed to the outer tube, the other end side of each of which is fixed to an innermost inner tube among the inner tubes, and a midway section of each of which is wound around each of the arm extension fixed sheaves and each of the arm extension

movable sheaves.

[0035] Further, the telescopic cylinder comprises a hydraulic cylinder including a tube, and a rod one side of which is fixed to a piston in the tube and the other side of which projects outside from the tube; a distal end part of the rod is attached to the outer tube of the telescopic arm in a state where the rod of the telescopic cylinder faces upward and the tube of the telescopic cylinder is formed as a free end; and the sheave mounting member is mounted to the tube of the telescopic cylinder.

[0036] According to this configuration, the rod of the telescopic cylinder is directed upward, and the distal end part of the rod is attached on the outer tube. Therefore, at the time of extending the telescopic cylinder, the tube as a large load and the sheave mounting member together move downward, and the inner tube is pulled up inside of the outer tube through the arm extension rope wound around the arm extension movable sheave and the arm extension fixed sheave. In this case, downward loads by the weight of the tube and the sheave mounting member act on the tube moving downward. As a result, the pulling-up force of the inner tube can be increased by using the weight of the tube and the sheave mounting member to efficiently perform the pulling-up operation of the inner tube by the telescopic cylinder.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0037] Fig. 1 is a side view showing a deep digging excavator in a state where a telescopic arm is contracted at the maximum according to an embodiment in the present invention.

Fig. 2 is a side view showing the deep digging excavator

in a state where the telescopic arm is extended at the maximum.

Fig. 3 is a side view showing the multistage telescopic arm device in Fig. 1 as a single member.

Fig. 4 is a front view showing the multistage telescopic arm device as viewed in a direction of arrows IV-IV in Fig. 3.

Fig. 5 is a perspective view showing the multistage telescopic arm device as a single member.

Fig. 6 is an enlarged perspective view of essential parts showing an outer tube, an telescopic cylinder, arm extension fixed sheaves, a sheave mounting member, arm extension movable sheaves, sheave mounting member guide rails, and the like in Fig. 5.

Fig. 7 is an enlarged perspective view of essential parts showing the sheave mounting member, the arm extension movable sheaves, pushing movable sheaves, the sheave mounting member guide rails, and the like.

Fig. 8 is an enlarged front view of essential parts shown by enlarging the arm extension fixed sheaves and the like in Fig. 4.

Fig. 9 is a schematic diagram showing a telescopic mechanism of the telescopic arm in a state where the telescopic arm is contracted.

Fig. 10 is a schematic diagram showing the telescopic mechanism of the telescopic arm in a state where the telescopic arm is extended.

Fig. 11 is a cross sectional view showing the telescopic arm, a boom bracket and the like as viewed in a direction of arrows XI-XI in Fig. 3

Fig. 12 is a cross sectional view showing the telescopic

arm, the telescopic cylinder, the sheave mounting member, the arm extension movable sheaves, and the like as viewed in a direction of arrows XII-XII in Fig. 3.

Fig. 13 is a cross sectional view showing the telescopic arm, the telescopic cylinder, the sheave mounting member, the pushing movable sheaves, and the like as viewed in a direction of arrows XIII-XIII in Fig. 3.

Fig. 14 is a cross sectional view showing the telescopic arm, sheave mounting openings, pushing fixed sheaves, and the like as viewed in a direction of arrows XIV-XIV in Fig. 3.

Fig. 15 is a side view showing a state where the deep digging excavator is set to a transport posture and the telescopic arm is placed on the ground.

Fig. 16 is a front view showing a modification where an telescopic cylinder, an arm extension fixed sheave, a sheave mounting member, an arm extension movable sheave, a sheave mounting member guide rail, and the like are arranged in a front surface side of an outer tube.

## MODE FOR CARRYING OUT THE INVENTION

[0038] Hereinafter, a deep digging excavator according to an embodiment in the present invention will be in detail explained with reference to the accompanying drawings.

[0039] In Fig. 1, designated at 1 is a deep digging excavator according to the present embodiment, and the deep digging excavator 1 has a vehicle body that includes an automotive lower traveling structure 2 of a crawler type and an upper revolving structure 3 that is mounted on the lower traveling structure 2

to be capable of revolving thereon. The vehicle body is a mount target of a multistage telescopic arm device 11 to be described later.

[0040] The upper revolving structure 3 is schematically configured of a revolving frame 3A as a base, a cab 3B arranged in a left front part of the revolving frame 3A, a counterweight 3C provided in a rear end side of the revolving frame 3A, and a housing cover 3D that accommodates therein onboard equipment of an engine, a hydraulic pump and the like (none of them are shown).

[0041] Indicated at 4 is a boom that is liftably provided in a front part side of the upper revolving structure 3. A base end side of the boom 4 is attached to the front part side of the revolving frame 3A, and the multistage telescopic arm device 11 to be described later is mounted to a distal end side of the boom 4. A boom cylinder 4A is provided between the boom 4 and the revolving frame 3A, and the boom 4 is lifted/tilted to the upper revolving structure 3 by extending/contracting the boom cylinder 4A. A digging device rocking cylinder 4B is attached at the bottom side on an upper surface side of the boom 4, and the digging device rocking cylinder 4B is attached at the rod side to the multistage telescopic arm device 11.

[0042] Next, an explanation will be made of the multistage telescopic arm device 11 that is mounted to the distal end side of the boom 4 and deeply excavates a vertical shaft on the ground.

[0043] Designated at 11 is the multistage telescopic arm device that is mounted to the distal end side of the boom 4, and the multistage telescopic arm device 11 includes a telescopic arm

12, an telescopic cylinder 25, a sheave mounting member 30, an arm extension fixed sheave 31, an arm extension movable sheave 33, and an arm extension rope 34.

[0044] Designated at 12 is the telescopic arm of a telescopic type that is mounted to the distal end side of the boom 4 to extend in vertical direction. The telescopic arm 12 includes, as shown in Fig. 9 and the like, an outer tube 13 positioned in the outermost side, a first-stage inner tube 21, which will be described later, accommodated in an inner peripheral side of the outer tube 13 to be extensible (movable) in the length direction, and a second-stage inner tube 23, which will be described later, accommodated in an inner peripheral side of the first-stage inner tube 21 to be extensible in the length direction.

[0045] Here, as shown in Fig. 11 to Fig. 14, the outer tube 13 is formed with a rear surface 13A that is attached to the distal end side of the boom 4, a front surface 13B that faces the rear surface 13A to be spaced from each other in the front-rear direction, a left side surface 13C and a right side surface 13D that are opposed to each other in the left-right direction having the rear surface 13A and the front surface 13B therebetween, a left inclined surface 13E that is arranged to be obliquely inclined between the rear surface 13A and the left side surface 13C, and a right inclined surface 13F that is arranged to be obliquely inclined between the rear surface 13A and the right side surface 13D. Therefore, the outer tube 13 is formed in an angular tube shape having a cross-section configuration of a hexagonal shape as a whole.

[0046] In this way, in the outer tube 13, the left inclined surface

13E is provided between the rear surface 13A attached to the distal end side of the boom 4 and the left side surface 13C, and the right inclined surface 13F is provided between the rear surface 13A and the right side surface 13D. Therefore, the outer tube 13 is configured such that the buckling strength of the outer tube 13 to loads acting thereon can be increased. On the other hand, an upper end part 13G and a lower end part 13H of the outer tube 13 each are formed as opening ends.

[0047] An upper flange plate 14 is provided to be integral with an outer peripheral side of the outer tube 13 to be positioned in the intermediate part in the length direction of the outer tube 13. One end 42A of a pushing rope 42 to be described later is fixed to the upper flange plate 14. On the other hand, a lower flange plate 15 is provided to be integral with a lower end part of the outer tube 13. One end 37A of a support rope 37 to be described later is fixed to the lower flange plate 15.

[0048] Left and right sheave mounting openings 16, 16' are formed in a lower part side of the outer tube 13. As shown in Fig. 14, the left sheave mounting opening 16 is formed in a section where the left side surface 13C and the left inclined surface 13E configuring part of the outer tube 13 intersect, and the right sheave mounting opening 16' is formed in a section where the right side surface 13D and the right inclined surface 13F of the outer tube 13 intersect. The sheave mounting openings 16, 16' are opened to an inside of the outer tube 13, and pushing fixed sheaves 39, 39' to be described later respectively are partially inserted into the sheave mounting openings 16, 16'.

[0049] Designated at 17 are a pair of left and right boom brackets

that are provided on a section of the outer tube 13 in the outside thereof and in a lower side than the sheave mounting member 30 to be described later, and the pair of boom brackets 17 are mounted to the distal end side of the boom 4. Here, the pair of boom  
5 brackets 17 are, as shown in Fig. 5 and Fig. 11, formed of plate bodies that are opposed to each other having an interval therebetween in the left-right direction, and the respective brackets 17 are fixed to both sides of a cylindrical boom connecting part 17A in the left-right direction. The pair of boom  
10 brackets 17 integrally bond to the rear surface 13A of the outer tube 13 using means of welding or the like, and the boom connecting part 17A of the boom brackets 17 is pin-connected to the distal end side of the boom 4 using a pin 18 (refer to Fig. 1). In addition, a gap 17B is formed between the pair of boom brackets 17, and  
15 the telescopic cylinder 25 to be described later is arranged in the gap 17B.

[0050] Designated at 19 are a pair of left and right cylinder brackets that are provided on the outside of the outer tube 13 to be position at an upper side than the boom bracket 17, and  
20 the pair of cylinder brackets 19 are mounted on the rod side of the digging device rocking cylinder 4B. Here, the pair of cylinder brackets 19 is formed of plate bodies that are opposed to each other having an interval therebetween in the left-right direction, and are provided with a cylinder connecting part to  
25 which a rod distal end part of the digging device rocking cylinder 4B is connected. The pair of cylinder brackets 19 integrally bond to the rear surface 13A of the outer tube 13 and in a position close to the upper side of the boom bracket 17 using means of

welding or the like, and the rod distal end part of the digging device rocking cylinder 4B is rotatably pin-connected to the cylinder connecting part of the pair of cylinder brackets 19 using a pin 20 (refer to Fig. 1).

5 [0051] Accordingly, the outer tube 13 of the telescopic arm 12 rocks in the front-rear direction or in the upper-lower direction at the distal end side of the boom 4 around the pin 18 by extending/contracting the digging device rocking cylinder 4B. It should be noted that the cylinder bracket 19 may be provided  
10 to be positioned in a lower side than the boom bracket 17 depending on a mounting position of the digging device rocking cylinder 4B.

[0052] Designated at 21 is the first-stage inner tube that is movably accommodated inside of the outer tube 13 with an  
15 appropriate gap from the outer tube 13 and is positioned in the outermost side. As shown in Fig. 11 to Fig. 14, the first-stage inner tube 21 has a cross-section configuration of a quadrangle surrounded by a rear surface 21A, a front surface 21B, a left side surface 21C and a right side surface 21D. The inner tube  
20 21 is formed as an angular tube body as a whole, and both end parts thereof in the upper-lower direction are formed as opening ends. Further, the inner tube 21 is accommodated inside of the outer tube 13 from the lower end part 13H of the outer tube 13, and is movable to the outer tube 13 in the length direction  
25 (upper-lower direction).

[0053] Here, slide plates (not shown) are provided between the inner side surface of the outer tube 13 and the outer side surface of the first-stage inner tube 21 to cause the inner tube 21 to

smoothly slide along the outer tube 13. On the other hand, a lower flange plate 22 is provided in the lower end part of the inner tube 21, and a support fixed sheave 35 to be described later is mounted to the lower flange plate 22.

5 [0054] Designated at 23 is a second-stage inner tube that is movably accommodated inside of the first-stage inner tube 21 with an appropriate gap therefrom and is positioned in the innermost side. The inner tube 23 is surrounded by a rear surface 23A, a front surface 23B, a left side surface 23C and a right side surface  
10 23D. The second-stage inner tube 23 is formed as an angular tube body having a cross-section configuration of a quadrangle a little smaller than the first-stage inner tube 21. The second-stage inner tube 23 is accommodated inside of the inner tube 21 from the lower end side of the first-stage inner tube 21, and is movable  
15 to the inner tube 21 in the length direction (upper-lower direction).

[0055] Here, slide plates (not shown) are provided between an inner side surface of the first-stage inner tube 21 and an outer side surface of the second-stage inner tube 23 to cause the inner  
20 tube 23 to smoothly slide along the inner tube 21. On the other hand, a mounting eye 24 is provided in a lower end part of the inner tube 23, and a clamshell bucket 43 to be described later is attached to the mounting eye 24.

[0056] Next, an explanation will be made of the telescopic  
25 cylinder 25, a tube guide 26 provided to the telescopic cylinder 25, the sheave mounting member guide rail 28, the sheave mounting member 30 and the like according to the present embodiment.

[0057] Denoted at 25 is the telescopic cylinder that is arranged

along the length direction of the outer tube 13 configuring part of the telescopic arm 12, and the telescopic cylinder 25 is composed of a hydraulic cylinder that extends/contracts by supply/discharge of pressurized oil. The telescopic cylinder 25 is configured of a tube 25A, a piston (not shown) that is slidably provided in the tube 25A, and a rod 25B one side of which is fixed to the piston in the tube 25A and the other side of which projects outside from the tube 25A.

[0058] Here, the telescopic cylinder 25 is arranged in the rear surface 13A side of the outer tube 13 to which the boom brackets 17 are provided and in the center position in the left-right direction of the outer tube 13 with the rod 25B facing upward. As shown in Fig. 8, a distal end part 25C of the rod 25B in the telescopic cylinder 25 is pin-connected through a pin 25D to a bracket 13J mounted to a section of the outer tube 13 close to an upper end part 13G thereof.

[0059] On the other hand, the tube 25A of the telescopic cylinder 25 extends downward as a free end, and is arranged in the gap 17B formed between the boom brackets 17 paired in the left-right direction. In addition, the sheave mounting member 30 to be described later is mounted to the upper part side of the tube 25A. Therefore, when the telescopic cylinder 25 extends/contracts between the maximum extension state shown in Fig. 1 and the maximum contraction state shown in Fig. 2, the tube 25A moves together with the sheave mounting member 30 in the upper-lower direction along the outer tube 13.

[0060] Here, in a case where the telescopic cylinder 25 is in the maximum conduction state shown in Fig. 2, when a length

dimension (length dimension of the telescopic cylinder 25 at the maximum contraction state) from a bottom part 25A1 of the tube 25A to the distal end part 25C (position of the pin 25D) of the rod 25B is indicated at L1, and a length dimension (length  
5 dimension of the outer tube 13) from an upper end portion 13G1 (position of the pin 25D where the rod 25B is connected to the outer tube 13) close to the upper end of the outer tube 13 to the lower end part 13H of the outer tube 13 is indicated at L2, the length dimension L1 of the telescopic cylinder 25 at the  
10 maximum contraction state is set to a nearly half length of the length dimension L2 of the outer tube 13.

[0061] That is, the length dimension L1 of the telescopic cylinder 25 at the maximum contraction state and the length dimension L2 of the outer tube 13 are set to the following relation.

15 [0062] (Formula 1)

$$\frac{2}{5}L2 < L1 < \frac{3}{5}L2$$

[0063] More preferably, the length dimension L1 of the telescopic cylinder 25 at the maximum contraction state and the length dimension L2 of the outer tube 13 are set to the following  
20 relation.

[0064] (Formula 2)

$$L1 \cong \frac{1}{2}L2$$

[0065] In this way, when the length dimension L1 of the telescopic cylinder 25 at the maximum contraction state is set to a nearly  
25 half length of the length dimension L2 of the outer tube 13, a large stroke of the telescopic cylinder 25 can be ensured.

Therefore, when the arm extension rope 34 is wound only four times between two fixed sheaves 31A, 31B of the arm extension fixed sheave 31 and two movable sheaves 33A, 33B of the arm extension movable sheave 33 that will be described later, the telescopic arm 12 can be extended/contracted between the maximum contraction state shown in Fig. 1 and the maximum extension state shown in Fig. 2.

[0066] Designated at 26 is the tube guide that is provided outside of the rear surface 13A of the outer tube 13, and the tube guide 26 can movably accommodate the tube 25A of the telescopic cylinder 25. As shown in Fig. 12 and Fig. 13, the tube guide 26 is formed with an angular tube body having a cross-section configuration of nearly a square. The tube guide 26 is arranged in the gap 17B formed between the pair of boom brackets 17, and is fixed to the rear surface 13A of the outer tube 13 in the length direction. Therefore, the tube 25A of the telescopic cylinder 25 as the free end can be guided by the tube guide 26 to move in the length direction of the outer tube 13.

[0067] Slide plates 27 are provided on an outer side surface at the bottom side of the tube 25A in the telescopic cylinder 25. The tube 25A of the telescopic cylinder 25 is inserted in an inner peripheral side of the tube guide 26, and the slide plate 27 moves along an inner peripheral surface of the tube guide 26. Therefore, the tube 25A can smoothly move in the length direction of the outer tube 13 along the tube guide 26.

[0068] Designated at 28 are the two sheave mounting member guide rails that are provided outside of the outer tube 13, and the respective sheave mounting member guide rails 28 guide the sheave

mounting member 30 to be described later. The two sheave mounting member guide rails 28 are arranged on the rear surface 13A of the outer tube 13 to be positioned in both sides of the telescopic cylinder 25 in the left-right direction one by one.

5 [0069] Here, the sheave mounting member guide rail 28 is formed with an angular tube body having a cross-section configuration of a rectangle. An upper end part of the sheave mounting member guide rail 28 is fixed through a bracket 28A to the proximity of the upper end part 13G of the outer tube 13, and a lower end  
10 part of the sheave mounting member guide rail 28 is fixed through a bracket 28B to the proximity of the upper flange plate 14 of the outer tube 13. Therefore, the sheave mounting member guide rail 28 extends in the length direction in parallel to the rear surface 13A in a state where a constant interval is formed to  
15 the rear surface 13A of the outer tube 13. In this case, since the two sheave mounting member guide rails 28 each formed of the angular tube body are fixed to the outer tube 13, the strength of the outer tube 13 can be increased.

[0070] Designated at 29 is a sheave mounting board that is fixedly  
20 provided to the upper end part 13G of the outer tube 13, and the arm extension fixed sheaves 31, 31' to be described later and the like are mounted to the sheave mounting board 29. Herein, the sheave mounting board 29 includes a sheave mounting part 29A extending from the rear surface 13A to the rear side (boom 4 side)  
25 of the outer tube 13, and a rope fixing part 29B positioned closer to the front side than the sheave mounting part 29A. The arm extension fixed sheaves 31, 31' are rotatably supported to the sheave mounting part 29A of the sheave mounting board 29, and

the one ends 34A, 34A' of the arm extension ropes 34, 34' to be described later are fixed to the rope fixing part 29B.

[0071] Designated at 30 is the sheave mounting member that is mounted to the tube 25A of the telescopic cylinder 25, and the arm extension movable sheaves 33, 33' and the pushing movable sheaves 41, 41' that will be described later are mounted to the sheave mounting member 30. Here, as shown in Fig. 7, Fig. 12 and Fig. 13, the sheave mounting member 30 is configured of a main body part 30A that is fixed to the upper part side of the tube 25A in the telescopic cylinder 25, upper sheave supporting parts 30B that are positioned in the upper part side of the main body part 30A and rotatably support the arm extension movable sheaves 33, 33', and lower sheave supporting parts 30C that are positioned in the lower part side of the main body part 30A and rotatably support the pushing movable sheaves 41, 41', which will be described herein after. The main body part 30A of the sheave mounting member 30 is bent in a mountain shape to avoid interference with the tube guide 26.

[0072] On the other hand, as shown in Fig. 12, left and right guide insertion parts 30D, each having an angular tube shape, into which the left and right sheave mounting member guide rails 28 are slidably inserted are mounted to the main body part 30A of the sheave mounting member 30, and the sheave mounting member 30 can be guided by the left and right sheave mounting member guide rails 28 to move in the length direction (upper-lower direction) of the outer tube 13.

[0073] Next, an explanation will be made of the configuration of telescopically connecting the first-stage inner tube 21 and

the second-stage inner tube 23 to the outer tube 13 configuring part of the telescopic cylinder arm 12, that is, the arm extension fixed sheaves 31, 31', the arm extension movable sheaves 33, 33', the arm extension ropes 34, 34', the support fixed sheaves 35, 35' and support ropes 37, 37'.

[0074] Here, the arm extension fixed sheaves 31, 31', the arm extension movable sheaves 33, 33', the arm extension ropes 34, 34', the support fixed sheaves 35, 35' and the support ropes 37, 37' are respectively provided bilaterally symmetrically with respect to the telescopic cylinder 25 to the outer tube 13, and have identical structures with each other. Therefore, hereinafter an explanation will be made of the arm extension fixed sheave 31, the arm extension movable sheave 33, the arm extension rope 34, the support fixed sheave 35, and the support rope 37 that are arranged in the left side of the outer tube 13, and ['] sign is attached to each of the corresponding components that are arranged in the right side of the outer tube 13, and the explanation is omitted.

[0075] Designated at 31 is the arm extension fixed sheave that is fixed to the upper end side of the outer tube 13 through the sheave mounting board 29, and the arm extension fixed sheave 31 is configured of the two fixed sheaves 31A, 31B each having an equal diameter. As shown in Fig. 8, the one fixed sheave 31A is rotatably supported to one bracket 32A of a bracket 32 provided to the sheave mounting part 29A of the sheave mounting board 29, and the other fixed sheave 31B is rotatably supported to the other bracket 32B. In this case, a support shaft (not shown) of each of the fixed sheaves 31A, 31B is arranged in non-parallel to the

rear surface 13A of the outer tube 13.

[0076] Designated at 33 is the arm extension movable sheave that is rotatably supported to the sheave mounting member 30, and the arm extension movable sheave 33 is configured of two movable  
5 sheaves 33A, 33B each having an equal diameter. Here, as shown in Fig. 12, the one movable sheave 33A and the other movable sheave 33B are rotatably supported adjacent to a single support shaft 33C provided to the upper sheave supporting parts 30B of the sheave mounting member 30. In this case, the support shaft 33C of each  
10 of the movable sheaves 33A, 33B is arranged in parallel to the rear surface 13A of the outer tube 13. The arm extension movable sheave 33 comes closer to or goes away from the arm extension fixed sheave 31 when the sheave mounting member 30 moves in the upper-lower direction in response to extension/contraction of  
15 the telescopic cylinder 25.

[0077] The arm extension movable sheave 33 supported to the sheave mounting member 30 is arranged closer to the outside than the left side surface 13C of the outer tube 13, and faces the left side surface 13C in the left-right direction, having a slight  
20 gap to the left side surface 13C. Therefore, it is possible to suppress the arm extension movable sheave 33 from largely projecting in the rear surface 13A side of the outer tube 13. As a result, it is possible to miniaturize the periphery of the arm extension movable sheave 33.

[0078] Designated at 34 is the arm extension rope for connection  
25 between the outer tube 13 and the second-stage inner tube 23 positioned in the innermost side, and the arm extension rope 34 is formed of a wire rope. Here, as shown in Fig. 9 and Fig. 10,

the one end 34A of the arm extension rope 34 is fixed to the rope fixing part 29B of the sheave mounting board 29 provided in the upper end part 13G of the outer tube 13, and the other end 34B of the arm extension rope 34 is fixed to the upper part side of the second-stage inner tube 23. In addition, the midway section of the arm extension rope 34 is wound four times between the two fixed sheaves 31A, 31B configuring the arm extension fixed sheave 31 and the two movable sheaves 33A, 33B configuring the arm extension movable sheave 33, respectively.

[0079] That is, the one end 34A of the arm extension rope 34 is fixed to the sheave mounting board 29, the midway section of the arm extension rope 34 is wound around the one movable sheave 33A of the arm extension movable sheave 33, the one fixed sheave 31A of the arm extension fixed sheave 31, the other movable sheave 33B of the arm extension movable sheave 33, and the other fixed sheave 31B of the arm extension fixed sheave 31, consecutively. Further, the arm extension rope 34 is inserted from the other fixed sheave 31B of the arm extension fixed sheave 31 into the outer tube 13 and the first-stage inner tube 21, and the other end 34B of the arm extension rope 34 is fixed to the upper part side of the second-stage inner tube 23.

[0080] In this way, the arm extension fixed sheave 31 is configured of the two fixed sheaves 31A, 31B and the arm extension movable sheave 33 is configured of the two movable sheaves 33A, 33B.

Based thereupon, the arm extension rope 34 is wound around the two fixed sheaves 31A, 31B and the two movable sheaves 33A, 33B four times in total. As a result, for example, as in the case of the conventional art, as compared to the configuration that

the arm extension rope is wound around the four sheaves of the arm extension fixed sheave and the four sheaves of the arm extension movable sheave eight times in total, the number of times by which the arm extension rope 34 comes in contact with the sheaves can be down by half.

[0081] Designated at 35 is a single support fixed sheave that is provided in the lower flange plate 22 of the first-stage inner tube 21. The support fixed sheave 35 is rotatably supported to a bracket 36 fixed to the lower flange plate 22 of the inner tube 21.

[0082] Designated at 37 is the support rope that supports the inner tube 21 between the outer tube 13 and the inner tube 23, and the support rope 37 is formed of a wire rope. Here, as shown in Fig. 9 and Fig. 10, the one end 37A of the support rope 37 is fixed to the lower flange plate 15 of the outer tube 13, and the midway section of the support rope 37 is wound around the support fixed sheave 35. Further, the support rope 37 is inserted from the support fixed sheave 35 into the first-stage inner tube 21, and the other end 37B of the support rope 37 is fixed to the upper part side of the second-stage inner tube 23.

[0083] Next, an explanation will be made of pushing mechanisms 38, 38' that push the first-stage inner tube 21 in the extension direction at the time of extending the inner tube 21 from the outer tube 13 by the telescopic cylinder 25.

[0084] That is, the left and right pushing mechanisms 38, 38' are provided between the outer tube 13 and the first-stage inner tube 21. Each of the pushing mechanisms 38, 38' holds the inner tube 21 in the extension state at the time of extending the inner

tube 21 from the outer tube 13 by the telescopic cylinder 25.  
[0085] Here, as shown in Fig. 13 and Fig. 14, the pushing mechanisms 38, 38' are configured of pushing fixed sheaves 39, 39', pushing movable sheaves 41, 41', and pushing ropes 42, 42'.

5 The respective pushing mechanisms 38, 38' are provided to be bilaterally symmetric with respect to the telescopic cylinder 25 to the outer tube 13, and have identical structures with each other. Therefore, hereinafter an explanation will be made of the pushing mechanism 38 that is arranged in the left side of the  
10 outer tube 13, and ['] sign is attached to each of the corresponding components that are arranged in the right side of the outer tube 13, and the explanation is omitted.

[0086] Designated at 39 is a single pushing fixed sheave that is provided in the lower part side of the outer tube 13. As shown  
15 in Fig. 14, the pushing fixed sheave 39 is rotatably supported to a bracket 40 fixed through a support shaft 39A to the outer tube 13 bridging over the sheave mounting opening 16 formed in the outer tube 13. In this case, the support shaft 39A of the pushing fixed sheave 39 is arranged at an inclination angle having  
20 an angle  $\theta$  smaller than 90 degrees to the left side surface 13C of the outer tube 13. That is, the support shaft 39A of the pushing fixed sheave 39 is arranged in non-parallel to the rear surface 13A of the outer tube 13, and a part of the pushing fixed sheave 39 supported by the support shaft 39A is accommodated inside of  
25 the outer tube 13.

[0087] Designated at 41 is a single pushing movable sheave that is provided in the sheave mounting member 30 in the lower position than the arm extension movable sheave 33. As shown in Fig. 13,

the pushing movable sheave 41 is rotatably supported through a support shaft 41A to the lower sheave supporting part 30C of the sheave mounting member 30. In this case, the support shaft 41A of the pushing movable sheave 41 is arranged in parallel to the rear surface 13A of the outer tube 13. The pushing movable sheave 41 comes closer to or goes away from the pushing fixed sheave 39 when the sheave mounting member 30 moves in the upper-lower direction in response to extension/contraction of the telescopic cylinder 25.

[0088] Designated at 42 is a pushing rope for connection between the outer tube 13 and the first-stage inner tube 21, and the pushing rope 42 is formed of a wire rope. Here, as shown in Fig. 9 and Fig. 10, one end 42A of the pushing rope 42 is fixed to the upper flange plate 14 of the outer tube 13, and midway sections of the pushing rope 42 are wound around the pushing movable sheave 41 and the pushing fixed sheave 39. Further, the other end 42B of the pushing rope 42 is inserted inside of the outer tube 13 from the pushing fixed sheave 39, and is fixed to the upper part side of the inner tube 21 inside of the outer tube 13.

[0089] Therefore, in a case the telescopic cylinder 25 is contracted from the maximum extension state shown in Fig. 1 and Fig. 9 to a state shown in Fig. 10, the tube 25A of the telescopic cylinder 25 moves upward together with the sheave mounting member 30, and the arm extension movable sheave 33 approaches the arm extension fixed sheave 31. As a result, the arm extension rope 34 wound around the arm extension movable sheave 33 and the arm extension fixed sheave 31 is reeled out, and the second-stage inner tube 23 extends downward from the outer tube 13 with its

own weight. Since the other end 37B of the support rope 37 fixed to the upper part side of the inner tube 23 moves down together with the second-stage inner tube 23 at this time, the first-stage inner tube 21 supported to the support rope 37 also extends  
5 downward from the outer tube 13 with its own weight. Thus, as shown in Fig. 2 and Fig. 10, when the tube 25A moves to the upper limit position and the telescopic cylinder 25 reaches the maximum contraction state, the telescopic arm 12 becomes in the maximum extension state.

10 [0090] Herein, when the sheave mounting member 30 approaches the arm extension fixed sheave 31, the pushing rope 42 is reeled between the pushing movable sheave 41 and the pushing fixed sheave 39, and the other end 42B of the pushing rope 42 moves downward with the first-stage inner tube 21. Therefore, the pushing rope  
15 42 all the time maintains a constant tension. In addition, since the inner tube 21 extends in a state of being supported to the support rope 37, the support rope 37 also all the time maintains a constant tension.

( [0091] Accordingly, when an excavating work is performed using  
20 the clamshell bucket 43 to be described later in a state where the inner tubes 21, 23 are extended from the outer tube 13, even in a case where an upward excavating reaction acts on the inner tubes 21, 23, the tension of the pushing rope 42 and the support rope 37 can suppress the inner tubes 21, 23 from moving to the  
25 contraction side.

[0092] Next, in a case the telescopic cylinder 25 is extended from the maximum contraction state shown in Fig. 2 and Fig. 10, the tube 25A of the telescopic cylinder 25 moves downward together

with the sheave mounting member 30, and the arm extension movable sheave 33 is separated from the arm extension fixed sheave 31. As a result, the arm extension rope 34 is reeled between the arm extension movable sheave 33 and the arm extension fixed sheave 31, and the second-stage inner tube 23 moves upward to be accommodated in the first-stage inner tube 21. At this time, since the other end 37B of the support rope 37 fixed to the upper part side of the inner tube 23 moves upward together with the inner tube 23, the first-stage inner tube 21 supported by the support rope 37 also moves upward to be accommodated in the outer tube 13. Thus, as shown in Fig. 1 and Fig. 9, when the tube 25A moves to the lower limit position and the telescopic cylinder 25 reaches the maximum extension state, the telescopic arm 12 becomes in the maximum contraction state.

[0093] On the other hand, at the time of contracting the telescopic arm 12 between the maximum extension state and the maximum contraction state, the arm extension fixed sheave 31', the arm extension movable sheave 33', the arm extension rope 34', the support fixed sheave 35', the support rope 37', and the pushing fixed sheave 39', the pushing movable sheave 41' and the pushing rope 42' configuring the pushing mechanism 38', which are arranged in the right side around the telescopic cylinder 25 are operable similarly as described above.

[0094] Here, as shown in Fig. 13 and Fig. 14, the outer tube 13 has a cross-section configuration of a hexagonal shape surrounded by the rear surface 13A, the front surface 13B, the left side surface 13C, the right side surface 13D, the left inclined surface 13E and the right inclined surface 13F, and the pushing movable

sheave 41 is arranged to face the left inclined surface 13E in the left-right direction. Therefore, as shown in the arrow X in Fig. 13, the pushing movable sheave 41 can be arranged to be close to the left inclined surface 13E. Preferably, it is desirable to provide the pushing movable sheave 41 in a position equivalent to the left side surface 13C or closer to the inside than the left side surface 13C. In this way, when the pushing movable sheave 41 is positioned close to the left inclined surface 13E of the outer tube 13, the left-right direction extension of the pushing movable sheave 41 to the left side surface 13C of the outer tube 13 can be suppressed, and besides, the front-rear direction extension of the pushing movable sheave 41 to the rear surface 13A of the outer tube 13 can also be suppressed.

[0095] On the other hand, in a case of arranging the pushing movable sheave 41 in this way, an angle  $\theta$  between the support shaft 39A of the pushing fixed sheave 39, around which and the pushing movable sheave 41 the pushing rope 42 is wound, and the left side surface 13C of the outer tube 13 can be made large. Therefore, as shown in an arrow Y in Fig. 14, a part of the pushing fixed sheave 39 accommodated in the outer tube 13 can be sufficiently separated from the inner tube 21. The projection amount of the pushing fixed sheave 39 from the left side surface 13C can be made small. As a result, without increasing a dimension between the left and right side surfaces 13C, 13D of the outer tube 13, a sufficient interval can be ensured between the pushing fixed sheave 39 and the first-stage inner tube 21 such that both thereof do not interfere to form the entire telescopic arm 12 in a compact. The above configuration can be

similarly applied to the pushing movable sheave 41' and the pushing rope 42' that are arranged in the right side around the telescopic cylinder 25.

5 [0096] Designated at 43 is the clamshell bucket that is mounted to the mounting eye 24 provided in the distal end side (lower end side) of the inner tube 23 to be able to be rocked thereto. The clamshell bucket 43 opens/closes by extending/contracting a bucket cylinder 44 to excavate earth and sand.

10 [0097] The deep digging excavator 1 according to the present embodiment has the configuration as described above, and hereinafter, an explanation will be made of the work of using the deep digging excavator 1 to excavate a vertical shaft 101 on the ground 100 to be deeply excavated.

15 [0098] First, as shown in Fig. 1, the deep digging excavator 1 extends the telescopic cylinder 25 at the maximum to contract the telescopic arm 12 at the maximum and hold the telescopic arm 12 in a vertical posture to the ground 100 on which the vertical shaft 101 is supposed to be excavated.

20 [0099] Next, as shown in Fig. 2, the telescopic cylinder 25 is contracted to set the telescopic arm 12 to the extension state. That is, the tube 25A of the telescopic cylinder 25 moves upward together with the sheave mounting member 30 to cause the arm extension movable sheave 33 to approach the arm extension fixed sheave 31. Thereby, the arm extension rope 34 wound around the  
25 two movable sheaves 33A, 33B of the arm extension movable sheave 33 and the two fixed sheaves 31A, 31B of the arm extension fixed sheave 31 is reeled out. As a result, the second-stage inner tube 23 extends downward from the outer tube 13 with its own weight,

and the first-stage inner tube 21 supported by the support rope 37 also extends downward from the outer tube 13 with its own weight.

[0100] At this time, the pushing rope 42 is reeled in between the pushing movable sheave 41 supported to the sheave mounting member 30 and the pushing fixed sheave 39, and thereby the pushing rope 42 maintains a constant tension all the time. Further, the support rope 37 that supports the first-stage inner tube 21 between the outer tube 13 and the second-stage inner tube 23 also maintains a constant tension all the time.

[0101] As a result, the tension of the pushing rope 42 and the support rope 37 can hold a state where the inner tubes 21, 23 are extended from the outer tube 13 to cause the clamshell bucket 43 to be pushed into a bottom surface 102 of the vertical shaft 101. In this state, by opening/closing the clamshell bucket 43 by the bucket cylinder 44, the clamshell bucket 43 can be used to deeply excavate the vertical shaft 101 and shovel a large deal of earth and sand.

[0102] After shoveling earth and sand by the clamshell bucket 43, the telescopic cylinder 25 is extended to cause the tube 25A of the telescopic cylinder 25 to move downward together with the sheave mounting member 30 and separate the arm extension movable sheave 33 from the arm extension fixed sheave 31.

[0103] As a result, the arm extension rope 34 is reeled in between the respective movable sheaves 33A, 33B of the arm extension movable sheave 33 and the respective fixed sheaves 31A, 31B of the arm extension fixed sheave 31, and the inner tube 23 moves upward to be accommodated in the inner tube 21. At this time,

since the other end 37B of the support rope 37 for connection between the outer tube 13 and the inner tube 23 moves upward together with the inner tube 23, the inner tube 21 supported by the support rope 37 also moves upward to be accommodated in the outer tube 13. As a result, the telescopic arm 12 becomes again in the maximum contraction state shown in Fig. 1.

[0104] Next, as shown in Fig. 1, after the telescopic cylinder 25 reaches the maximum extension state and the telescopic arm 12 becomes in the maximum contraction state, the distal end side of the boom 4 is lifted up to pull the clamshell bucket 43 out of the vertical shaft 101. In addition, after revolving the upper revolving structure 3 toward a predetermined soil discharging position in a state where the lower traveling structure 2 is stopped, earth and sand grasped by the clamshell bucket 43 are discharged to the soil discharging position.

[0105] Here, in the deep digging excavator 1 according to the present embodiment, the distal end part 25C of the rod 25B in the telescopic cylinder 25 is pin-connected to the bracket 13J provided on the outer tube 13 of the telescopic arm 12 by using the pin 25D. On the other hand, the sheave mounting member 30 that supports the arm extension movable sheave 33 and the pushing movable sheave 41 is mounted to the tube 25A of the telescopic cylinder 25 as the free end. Therefore, when the telescopic cylinder 25 is extended for lifting up earth and sand excavated by the clamshell bucket 43, the tube 25A as the weight load moves downward together with the sheave mounting member 30.

[0106] Thereby, the downward load by the weight of the tube 25A and the sheave mounting member 30 acts on the arm extension rope

34 wound around the arm extension movable sheave 33 and the arm extension fixed sheave 31. As a result, the telescopic arm 12 can increase the pulling-up forces of the inner tubes 21, 23 using the weight of the tube 25A and the sheave mounting member 30 to efficiently perform the pulling-up operation of the inner tubes 21, 23 by the telescopic cylinder 25.

[0107] In the deep digging excavator 1 according to the present embodiment, the arm extension fixed sheave 31 is configured of the two fixed sheaves 31A, 31B, and the arm extension movable sheave 33 is configured of the two movable sheaves 33A, 33B. In addition, the arm extension rope 34 is wound around the two fixed sheaves 31A, 31B and the two movable sheaves 33A, 33B four times in total. As a result, as compared to the configuration in which the arm extension rope is wound around the four sheaves of the arm extension fixed sheave and the four sheaves of the arm extension movable sheave eight times in total, for example as in the case of the conventional art, it is possible to extend the lifetime of the arm extension rope.

[0108] In addition, the arm extension rope 34 is wound around the two fixed sheaves 31A, 31B configuring the arm extension fixed sheave 31 and the two movable sheaves 33A, 33B configuring the arm extension movable sheave 33 four times in total. As a result, the pulling-up amount of the inner tubes 21, 23 using the arm extension rope 34 can be made four times as many as the stroke amount of the telescopic cylinder 25 to pull up the inner tubes 21, 23 efficiently.

[0109] According to the present embodiment, the rod 25B of the telescopic cylinder 25 is fixed in the upper part side of the

outer tube 13 and under the arm extension fixed sheave 31. Therefore, the tube 25A of the telescopic cylinder 25 to which the sheave mounting member 30 is mounted can move in the upper-lower direction within a range in nearly an upper half of the outer tube 13 extending in the upper-lower direction. Therefore, for example, as shown in Fig. 1, even in a case where a lower half of the outer tube 13 is under the ground at the time of excavating the vertical shaft 101, an operator in a cab 3B of the upper revolving structure 3 can visually confirm the telescopic operation of the telescopic cylinder 25 and the like. As a result, the workability and safety of the excavating work using the deep digging excavator 1 can be enhanced.

[0110] According to the present embodiment, the two sheave mounting member guide rails 28 are fixed to the outside of the outer tube 13 in a state of extending in the length direction in parallel to the outer tube 13. On the other hand, the sheave mounting member 30 moves in the length direction of the outer tube 13 along the sheave mounting member guide rail 28 in response to the extension of the telescopic cylinder 25.

[0111] Accordingly, the sheave mounting member 30 can be guided by the sheave mounting member guide rails 28 to move on a constant track all the time. As a result, the arm extension rope 34 wound around the arm extension fixed sheave 31 and the arm extension movable sheave 33 can smoothly follow up the movement of the arm extension movable sheave 33, and therefore, the safety of the telescopic operation of each of the inner tubes 21, 23 to the outer tube 13 can be enhanced. In addition, since the two sheave mounting member guide rails 28 are fixed to the outer tube 13,

the strength of the outer tube 13 can be enhanced by the two sheave mounting member guide rails 28 to enhance the reliability of the entire telescopic arm 12.

[0112] On the other hand, the tube 25A of the telescopic cylinder 25 to which the sheave mounting member 30 is mounted can move on a constant track along the sheave mounting member guide rails 28. As a result, the strength of the telescopic cylinder 25 to the buckling and the lateral load acting thereon can be increased to enhance the reliability of the telescopic cylinder 25.

[0113] According to the present embodiment, the pair of boom brackets 17 are provided on the rear surface 13A of the outer tube 13 positioned in the cab 3B side of the upper revolving structure 3, and are mounted on the distal end side of the boom 4. In addition thereto, the telescopic cylinder 25 is arranged between the pair of boom brackets 17.

[0114] Thereby, the sheave mounting member 30 mounted to the tube 25A of the telescopic cylinder 25, the arm extension movable sheave 33 supported to the sheave mounting member 30, the arm extension rope 34 wound around the arm extension fixed sheave 31 and the arm extension movable sheave 33, and the like can be arranged in a position of facing the cab 3B of the upper revolving structure 3. As a result, an operator in the cab 3B can extend/contract the inner tubes 21, 23 to the outer tube 13 while visually confirming the telescopic cylinder 25 and the like, thus making it possible to accurately perform the telescopic operation.

[0115] Since the boom brackets 17 are provided on the rear surface 13A of the outer tube 13, it is not necessary to provide the

telescopic cylinder 25, the arm extension fixed sheave 31, the sheave mounting member 30, the arm extension movable sheave 33 and the like on the front surface 13B of the outer tube 13.

Therefore, at the excavating the vertical shaft 101, the  
5 telescopic cylinder 25 and the like do not come in contact with obstacles to be damaged, thus making it possible to enhance the workability of the excavating work.

[0116] On the other hand, as shown in Fig. 15, since the boom brackets 17 are provided on the rear surface 13A of the outer  
10 tube 13, the front surface 13B of the outer tube 13 can be placed on the ground for setting the deep digging excavator 1 in a transport posture. As a result, without using a particular platform or the like, the telescopic cylinder 25, the sheave mounting member 30, the arm extension fixed sheave 31, the arm  
15 extension movable sheave 33 and the like can be held in the upward posture where no weight of the telescopic arm 12 acts.

[0117] Accordingly, the maintenance work to the telescopic cylinder 25, the arm extension fixed sheave 31, the sheave mounting member 30, the arm extension movable sheave 33 and the  
20 like that are mounted on the outer tube 13 can be performed in a position close to the ground in a state where the deep digging excavator 1 is set to the transport posture. Therefore, the workability of the maintenance work can be enhanced.

[0118] According to the present embodiment, the tube guide 26  
25 in an angular tube shape is provided on the rear surface 13A of the outer tube 13, and the tube 25A of the telescopic cylinder 25 is movably (slidably) accommodated in the tube guide 26. Therefore, the tube 25A of the telescopic cylinder 25 as the free

end can be guided in the length direction of the outer tube 13 by the tube guide 26. Accordingly, even in a case where the sheave mounting member 30 is mounted to the tube 25A, the tube 25A can be smoothly moved along the tube guide 26.

5 [0119] In addition, since the tube 25A of the telescopic cylinder 25 can move on a constant track along the tube guide 26, the strength of the telescopic cylinder 25 to the buckling and later loads acting thereon can be increased. Further, the tube 25A can be protected from falling rocks or the like due to the excavating  
10 work of the vertical shaft 101 by accommodating the tube 25A in the tube guide 26.

[0120] According to the present embodiment, the outer tube 13 is formed in the tubular shape having the cross-section configuration of the hexagonal shape, and the outer tube 13 is  
15 configured such that the left and right inclined surfaces 13E, 13F are provided between the rear surface 13A and the left and right side surfaces 13C, 13D. Thereby, the buckling strength of the outer tube 13 to the load acting thereon can be increased to extend the lifetime of the outer tube 13, and therefore, the  
20 reliability of the entire telescopic arm 12 can be enhanced.

[0121] In addition, since the arm extension movable sheave 33 is arranged closer to the outside than the left side surface 13C of the outer tube 13, the arm extension movable sheave 33 faces the left side surface 13C of the outer tube 13 with a slight  
25 interval in the left-right direction. Thereby, it is possible to suppress the arm extension movable sheave 33 from largely projecting in the rear surface 13A side of the outer tube 13, and even in a case of using the arm extension movable sheave 33

having the movable sheaves 33A, 33B each having a large diameter, the periphery of the arm extension movable sheave 33 can be miniaturized. As a result, it is possible to extend the lifetime of the arm extension rope 34 by using the arm extension movable sheave 33 provided with the movable sheaves 33A, 33B each having a large diameter. It should be noted that the arm extension movable sheave 33' can obtain an effect similar to the above-mentioned effect by arranging the arm extension movable sheave 33' closer to the outside than the right side surface 13D of the outer tube 13.

[0122] In this way, since the deep digging excavator 1 according to the present embodiment has the structure of being able to extend the lifetime of the arm extension rope 34, it is possible to set the load acting on the arm extension rope 34 to be large. As a result, it is possible to hoist large loads by the second-stage inner tube 23 to which the arm extension rope 34 is connected, and it is possible to increase the volume of the clamshell bucket 43 attached to the distal end side of the inner tube 23, and thus enhancing the excavating efficiency by excavating a large deal of earth and sand.

[0123] Further, according to the deep digging excavator 1 in the present embodiment, the sheave mounting openings 16, 16' are provided to the lower part side of the outer tube 13, and a part of each of the pushing fixed sheaves 39, 39' is arranged inside of the outer tube 13 through each of the sheave mounting openings 16, 16'. As a result, in a case of setting each diameter of the pushing fixed sheaves 39, 39' to be large, the pushing fixed sheaves 39, 39' can be mounted to the outer tube 13 compactly.

As a result, it is possible to extend the lifetime of the pushing ropes 42, 42' by using the pushing fixed sheaves 39, 39' each having a large diameter.

[0124] In addition, since the pushing fixed sheaves 39, 39' are arranged to be positioned in the sheave mounting openings 16, 16' provided in the lower part side of the outer tube 13, it is not necessary to arrange the pushing fixed sheave in the lower end part of the outer tube as in the case of the conventional art. Therefore, even in a case where the first-stage inner tube 21 is accommodated in the outer tube 13, the lower flange plate 22 provided in the lower end part of the inner tube 21 does not interfere with the pushing fixed sheaves 39, 39'. Accordingly, it is possible to cause the lower flange plate 22 of the inner tube 21 to approach the lower end part 13H of the outer tube 13, that is, close vicinity to the lower flange plate 15. As a result, the entire length of the telescopic arm 12 at the maximum contraction can be shortened to put the deep digging excavator 1 in the compact transport posture at the time of transporting the deep digging excavator 1, for example.

[0125] It should be noted that the aforementioned embodiment shows an example of the configuration such that the telescopic cylinder 25, the sheave mounting member guide rail 28, the sheave mounting member 30, the arm extension fixed sheave 31, the arm extension movable sheave 33 and the like are arranged on the rear surface 13A side to which the boom bracket 17 is mounted in the outer tube 13 configuring part of the telescopic arm 12. However, the present invention is not limited thereto, and may be configured as a modification shown in Fig. 16, for example. That is, the

telescopic cylinder 25, the sheave mounting member guide rail 28, the sheave mounting member 30, the arm extension fixed sheave 31, the arm extension movable sheave 33 and the like may be arranged on the front surface 13B side of the outer tube 13.

5 Therefore, an operator who is familiar with the existing telescopic arm has no strange feeling at the time of operating the deep digging excavator, thus making it possible to enhance the operability.

[0126] The aforementioned embodiment shows an example of the  
10 configuration such that the arm extension fixed sheaves 31, 31', the arm extension movable sheaves 33, 33', the arm extension ropes 34, 34', the support fixed sheaves 35, 35', the support ropes 37, 37', the pushing fixed sheaves 39, 39', the pushing movable sheaves 41, 41', the pushing ropes 42, 42' and the like are  
15 respectively provided bilaterally symmetric around the telescopic cylinder 25 to the outer tube 13. However, the present invention is not limited thereto, and each component of the arm extension fixed sheave 31, the arm extension movable sheave 33, the arm extension rope 34, the support fixed sheave 35, the support  
20 rope 37, the pushing fixed sheave 39, the pushing movable sheave 41, the pushing rope 42, and the like may be provided in the central part of the outer tube 13 in the left-right direction.

[0127] Further, the aforementioned embodiment shows an example of a case where the sheave mounting member guide rail 28 that  
25 guides the sheave mounting member 30 is formed in the angular tube body having the cross-section configuration of the rectangle. However, the present invention is not limited thereto, and a sheave mounting member guide rail may be formed using a steel

material having a cross-section configuration in an L-letter shape, for example.

#### DESCRIPTION OF REFERENCE NUMERALS

- 5 [0128]2: Lower traveling structure (Vehicle body)
- 3: Upper revolving structure (Vehicle body)
- 4: Boom
- 12: Telescopic arm
- 13: Outer tube
- 10 13A: Rear surface
- 13B: Front surface
- 13C: Left side surface
- 13D: Right side surface
- 13E: Left inclined surface
- 15 13F: Right inclined surface
- 13G: Upper end part
- 13H: Lower end part
- 16: Sheave mounting opening
- 17: Boom bracket
- 20 21: First-stage inner tube
- 23: Second-stage inner tube
- 25: Telescopic cylinder
- 25A: Tube
- 25B: Rod
- 25 26: Tube guide
- 28: Sheave mounting member guide rail
- 30: Sheave mounting member
- 31, 31': Arm extension fixed sheave

33, 33': Arm extension movable sheave  
34, 34': Arm extension rope  
35, 35': Support fixed sheave  
38, 38': Pushing mechanism  
5 39, 39': Pushing fixed sheave  
41, 41': Pushing movable sheave  
42, 42': Pushing rope

## CLAIMS

1. A multistage telescopic arm device comprising:

5 a telescopic arm that is provided on a distal end side of a boom of a mount target to be extendible in the upper-lower direction and includes an outer tube and multistage inner tubes accommodated inside of said outer tube to be extensible in the length direction;

10 a telescopic cylinder that is provided along the length direction of said outer tube configuring part of said telescopic arm;

arm extension fixed sheaves that are fixedly provided on said outer tube;

15 a sheave mounting member that is mounted on said telescopic cylinder and movably supported to said outer tube in the length direction of said outer tube in such a manner as to come close to or be away from said arm extension fixed sheaves;

20 arm extension movable sheaves that are provided on said sheave mounting member; and

arm extension ropes one end side of each of which is fixed to said outer tube, the other end side of each of which is fixed to an innermost inner tube of said inner tubes , and a midway section of each of which is wound around each of said arm extension fixed sheaves and each of said arm extension movable sheaves, characterized in that:

25

said telescopic cylinder is configured of a hydraulic cylinder comprising a tube, and a rod one side of which is

fixed to a piston in said tube and the other side of which projects outside from said tube,

5 a distal end part of said rod is attached to said outer tube of said telescopic arm in a state where said rod of said telescopic cylinder faces upward and said tube of said telescopic cylinder is formed to be movable in the length direction of said outer tube, and

said sheave mounting member is mounted to said tube of said telescopic cylinder.

10

2. The multistage telescopic arm device according to claim 1, wherein the distal end part of said rod in said telescopic cylinder is attached to an upper part side of said outer tube.

15

3. The multistage telescopic arm device according to claim 1, wherein a sheave mounting member guide rail is provided outside of said outer tube, said sheave mounting member guide rail being mounted on said outer tube to extend in the length direction in parallel to said outer tube, and

20 said sheave mounting member moves along said sheave mounting member guide rail in response to extension and contraction of said telescopic cylinder.

25 4. The multistage telescopic arm device according to claim 1, wherein a pair of boom brackets are provided outside of said outer tube and in a lower section of said outer tube than said sheave mounting member, said pair of boom brackets

facing with each other with an interval in the left-right direction and being mounted to the distal end side of said boom to be able to be rocked thereto, and

said tube of said telescopic cylinder is arranged in  
5 a gap formed between said pair of boom brackets.

5. The multistage telescopic arm device according to claim 1, wherein a tube guide is provided outside of said outer tube to movably accommodate said tube of said telescopic  
10 cylinder and guide said tube in the length direction of said outer tube.

6. The multistage telescopic arm device according to claim 1, wherein said outer tube is formed in an angular tube  
15 shape having a cross-section configuration of a polygonal shape including at least a rear surface attached to a distal end side of said boom, a front surface facing said rear surface in the front-rear direction, a left side surface and a right side surface that are opposed to each other in the left-right  
20 direction having said rear surface and said front surface therebetween, a left inclined surface arranged to be obliquely inclined between said rear surface and said left side surface, and a right inclined surface arranged to be obliquely inclined between said rear surface and said right  
25 side surface, and

said arm extension movable sheaves are arranged closer to the outside in the left-right direction than said left and right side surfaces configuring part of said outer tube.

7. The multistage telescopic arm device according to claim 1, wherein said outer tube is formed in an angular tube shape having a cross-section configuration of a hexagonal shape including a rear surface attached to a distal end side of said boom, a front surface facing said rear surface in the front-rear direction, a left side surface (13C) and a right side surface that are opposed to each other in the left-right direction having said rear surface and said front surface therebetween, a left inclined surface arranged to be obliquely inclined between said rear surface and said left side surface, and a right inclined surface arranged to be obliquely inclined between said rear surface and said right side surface.

8. The multistage telescopic arm device according to claim 1, wherein pushing mechanisms are provided between said outer tube and a first-stage inner tube positioned in the outermost side among said multistage inner tubes, said pushing mechanisms pushing in said first-stage inner tube in the extension direction at the time of extending said first-stage inner tube from said outer tube by said telescopic cylinder,

said pushing mechanisms respectively includes:

pushing fixed sheaves provided in said outer tube to be positioned in a lower part side of said outer tube ;

pushing movable sheaves provided in said sheave mounting member in a lower position than said arm extension movable sheaves; and

pushing ropes one end side of each of which is fixed to said outer tube, the other end side of each of which is fixed to said first-stage inner tube through an inside of said outer tube, and a midway section of each of which is wound around each of said pushing fixed sheaves and each of  
5 said pushing movable sheaves,

sheave mounting openings are provided in the lower part side of said outer tube and in positions where said pushing fixed sheaves are provided, and

10 a part of each of the pushing fixed sheaves is arranged inside of said outer tube through each of said sheave mounting openings.

9. A deep digging excavator including an automotive  
15 vehicle body, a boom liftably provided on said vehicle body , and a multistage telescopic arm device provided in a distal end side of said boom,

wherein said multistage telescopic arm device comprising:

20 a telescopic arm that includes an outer tube extending in the upper-lower direction and multistage inner tubes accommodated inside of said outer tube to be extensible in the length direction;

a telescopic cylinder that is arranged along the length  
25 direction of said outer tube configuring part of said telescopic arm;

arm extension fixed sheaves that are fixedly provided on said outer tube;

a sheave mounting member that is mounted on said telescopic cylinder and movably supported to said outer tube in the length direction of said outer tube in such a manner as to come close to or be away from said arm extension fixed sheaves;

arm extension movable sheaves that are provided on said sheave mounting member; and

arm extension ropes one end side of each of which is fixed to said outer tube, the other end side of each of which is fixed to an innermost inner tube among said inner tubes, and a midway section of each of which is wound around each of said arm extension fixed sheaves and each of said arm extension movable sheaves, characterized in that:

said telescopic cylinder comprises a hydraulic cylinder including a tube, and a rod one side of which is fixed to a piston in said tube and the other side of which projects outside from said tube;

a distal end part of said rod is attached to said outer tube of said telescopic arm in a state where said rod of said telescopic cylinder faces upward and said tube of said telescopic cylinder is formed to be movable in the length direction of said outer tube; and

said sheave mounting member is mounted to said tube of said telescopic cylinder.