(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 486 616 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
15.12.2004 Bulletin 2004/51

(21) Application number: **03703220.8**

(22) Date of filing: **06.02.2003**

(51) Int Cl.[7]: **E02D 3/12**

(86) International application number:
PCT/JP2003/001256

(87) International publication number:
WO 2003/072882 (04.09.2003 Gazette 2003/36)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT SE SI SK TR
Designated Extension States:
AL LT LV MK RO

(30) Priority: **27.02.2002 JP 2002052189**

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(54) WIRE TYPE EXCAVATING ACCURACY CONTROL DEVICE OF SOIL IMPROVING MACHINE

(57) A wire type excavating accuracy control device for surely assuring specified lapped amounts between piles in soil column rows by correcting or controlling the tip position of the excavating and agitating blade shaft (6) or a soil improving machine, comprising a three-dimensional gyro sensor device installed near a bearing member (11) for detecting the tip position of the excavating and agitating blade shaft (6), a construction control device (22) for inputting, therein, measurement signals (23) for the tip position of the excavating and agitating blade shaft (6) measured by the three dimensional gyro sensor device, and a hydraulic control circuit of hydraulic cylinders (10) controlled by the control signals, calculated and processed based on the measurement signals (23) by the construction control device (22), wherein the applicable hydraulic cylinders (10) are controlled independently of each other to pull wires (12) therefor so as to forcibly correct and control the tip position of the excavating and agitating shaft (6).

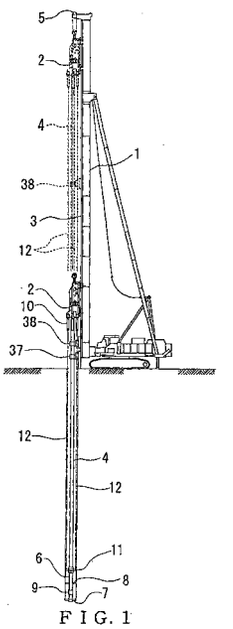

FIG. 1

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Description

Technical Field

[0001] The present invention relates to a technical field of a wire type excavating accuracy control device for accurately assessing the specified lap amounts between piles in soil columns by forcibly correcting or controlling the tip position of an excavating and agitating blade shaft of a soil improving machine used for constructing lapped type piles in soil columns, in real time, at the construction site for purposes of building earth-retaining walls, foundation work for civil engineering and construction, construction for preventing the liquefaction of soil, building cut-off walls and the like.

Background Art

[0002] Various kinds of soil improving construction have conventionally been performed using a soil improving machine, as shown in FIG. 1, for example. According to this machine, by means of a digging drive 2 that is suspended on the top sheave 5 of a leader 1 that is moved vertically along a rail 3, a drive shaft 4 suspended directly thereunder is driven by rotation and propelled perpendicularly downward at the same time. The drive shaft 4 has a lower end connected to an excavating and agitating blade shaft 6 provided with a tip-end cutter 7 and a plurality of agitating blades 8 above and below. When the excavating and agitating blade shaft 6 is propelled to dig or pulled up while being rotated at the same time, the excavation soil and the stabilizer are agitated, and mixed to form piles in soil columns, each having a diameter of about one meter. In the case of lapped type piles in soil columns, the soil improvement is carried out wherein two adjacent piles are lapped over each other by a lap length (also referred to as a lap width) of about 20 cm so as to be integrally continuous,. In order to secure the perpendicular plumbing accuracy of the drive shaft 4, steady braces are provided 37, 38 for the drive shaft in the lower and middle portions of the leader 1. Each of the steady braces 37, 38 also vertically moves along the rail 3.

[0003] In various kinds of soil improving construction using a soil improving machine, when there is not enough lap length between two adjacent piles in the soil columns (improving piles) or when the piles are not lapped at all, the integrality (continuity) of the improving piles is diminished, thereby resulting in poor construction causing a reduction in structural strength and rigidity of the improved soil, unsatisfactory water cut-off ability, etc.

[0004] In view of the aforementioned, a variety of excavating accuracy control methods and devices has been studied as measures to surely assure the specified lapped amounts between the piles in soil columns. This relates to a technology of position-correcting the tip position of the excavating and agitating blade shaft in real time at the construction site. Conventional technologies in this field include the following inventions.

(1) An invention called "method and device for controlling excavating accuracy of a multishaft soil column row excavating machine" that is disclosed in Japanese Patent No. 2736471 (filed on June 8, 1990; Unexamined Japanese Patent Publication No. H4(1992)-44592) has a configuration in which the upper and lower portions of an excavating shaft are coupled by a plurality of wires, and a moving amount of each wire is controlled by using the hydraulic control device.

(2) According to the invention called "construction control method of lap length between soil columns" that is disclosed in Japanese Patent No. 3156049 (filed on November 27, 1998, Unexamined Japanese Patent Publication No. 2000-160549), a three-dimensional gyro sensor for measuring the tip position of an excavating and agitating blade shaft is installed near the upper portion of the excavating and agitating blade shaft. A global positioning system for measuring self-location through the use of a so-called GPS is also installed. If the measurement means measures the curving tendency of the excavating and agitating blade shaft when the lapped-type piles in soil columns are constructed, a tip-end excavation cutter is reversed to implement position correction. During the construction of an adjacent pile of soil column lapped over the one previously constructed, the actual lap length is understood and controlled based on the horizontal distance and horizontal sectional shape of the previous and subsequent construction records (construction loci). This invention relates to a method and a soil improving apparatus for carrying out position correction by reversing the tip-end excavation cutter if an error in the lap length, curving tendency or the like are found.

(3) The invention called "soil improving construction method and device" that is disclosed in Unexamined Japanese Patent Publication No. 2001-254388 (filed on March 14, 2000) has a configuration in which a joint portion between the drive shaft and the excavating and agitating blade shaft of the soil improving machine is formed into an adjustable joint that is capable of transmitting the running torque, and it is possible to correct the position of an excavating and agitating blade shaft by means of at least three hydraulic cylinders. The invention is so configured that the excavating direction can be corrected during measurement by way of a measurement means using a three-dimensional gyro sensor.

(4) The invention called "lower connection band for an agitating excavating shaft" that is disclosed in Unexamined Japanese Patent Publication No. 2002-146771 (filed on November 15, 2000) has an

adjustable structure in which bearings of the lower connection band, (referred to by numeral 9 in FIG. 1), for securing the distance between a plurality of excavating and agitating blade shafts are coupled to one another with horizontal pins so as to be deformable for the purpose of facilitating directional control on the excavating and agitating blade shafts in the lateral direction.

(5) The invention called "excavating accuracy control method" that is disclosed in Unexamined Japanese Patent Publication No. 2002-167749 (filed on December 4, 2000) is a wire-type control method. Although the invention "method for controlling excavating accuracy of a multishaft soil column row excavating machine" disclosed in the above-mentioned document (1), namely Japanese Patent No. 2736471, is simply capable of implementing directional control on the excavating and agitating blade shaft in the anteroposterior direction (lateral direction in FIG. 1), the subject invention additionally enables control in the lateral direction (perpendicular direction, facing into FIG. 1), which improves accuracy.

[0005] When the construction of the lapped-type piles in soil columns is carried out by means of the soil improving machine, as a measure to prevent poor construction in which there is insufficient lap length or no lap between piles in soil columns, it has been common to perform construction with an extra lap length that is greater than the lap length required by design. This increases the volume of soil improvement along a reduction in the pitch of the soil improving piles, which is inefficient and uneconomical.

[0006] Considering the above problem, the improvement technologies as seen in documents (1) through (5) have been studied. These technologies, however, cannot be said to have achieved enough to resolve the related problems.

[0007] To be concrete, although the control method described in document (1) is configured to control the movement amount of the wires by using a hydraulic control device, a critical control targeted value is determined by an indirect measurement method based on the movement amount of the wires. Thus, there is some doubt as to whether it is possible to attain a control result corresponding to an error of the tip position of the excavating shaft.

[0008] The construction control method stated in document (2) is innovative in that the three-dimensional gyro sensor is employed, and that the actual lap length is understood and controlled in real time by means of the global positioning system for measuring the self-location through the use of the GPS. As means for position correction, however, the position correction is carried out simply by reversing the tip-end excavation cutter. Consequently, the invention has the drawback of being difficult with respect to providing a prompt and reliable response.

[0009] The soil improving construction method described in document (3) has greater possibility of a prompt and reliable response, compared to the above-described two inventions, in that the measurement is carried out by a measurement means using a three-dimensional gyro sensor, and that the joint portion between the drive shaft and the excavating and agitating blade shaft of the soil improving machine is formed into an adjustable joint capable of transmitting the running torque to enable the position correction of the excavating and agitating blade shaft by using at least three hydraulic cylinders. Because of the configuration in which delicate machine parts (adjustable joint, hydraulic cylinders, etc.) are propelled deep into the excavation soil, however, there are problems securing durability, maintenance and inspection.

[0010] The usefulness of the lower connection band mentioned in document (4) can be fully recognized. On the other hand, an excavating accuracy control method in which the band is well applied has not yet been accomplished.

[0011] The excavating accuracy control method disclosed in document (5) is noteworthy in that it is a wire type control method. However, the relevance to the technology of position measurement of the excavating and agitating blade shaft is obscure.

[0012] As is apparent from the examination and consideration of each invention as stated above, conventional technologies each have their own characteristics. On the other hand, they lack technological substance sufficient to be immediately practicable in the field through totalization of a comprehensive system.

[0013] An object of the present invention consists in providing a wire type excavating accuracy control device for a soil improving machine, which incorporates the technology for detecting the tip position of the excavating and agitating blade shaft by means of a three-dimensional gyro sensor described in document (2) while making use of the advantages of a wire type excavating accuracy control method, thereby being capable of detecting a position (locus) of an improving pile previously constructed and subsequently a tip position of an excavating shaft of an improving pile to be lapped thereover, in real time, and in the event that the positions show a tendency to deviate from planned positions during construction, performing immediate directional correction of the tip position under precise and responsive control, implementing real-time position correction at the construction, securing required or appropriate lapped amounts and controlling plumbing accuracy.

[0014] Another object of the present invention is to provide a wire type excavating accuracy control device for a soil improving machine that makes it possible to accurately secure specified lapped amounts between piles in soil columns without difficulty, to carry out efficient construction with lap length required by design, and to perform construction with proper pitch of soil im-

proving piles, to thereby realize efficient and economical soil improving construction.

Disclosure of the Invention

[0015] To accomplish the above object, a wire type excavating accuracy control device in a soil improving machine according to the invention claimed in claim 1, consists of a plurality of wires or the like 12 arranged around a drive shaft 4 and coupled between hydraulic cylinders 10 suspended under a digging drive 2 for rotating-driving the drive shaft 4 of the soil improving machine to propel the drive shaft 4 along a leader 1 perpendicularly downward and a bearing member 11 disposed in a portion directly above an excavating and agitating blade shaft 6 connected to a lower end of the drive shaft 4, and corrects and controls the tip position of the excavating and agitating blade shaft 6 by pulling the wires or the like 12 individually by means of the hydraulic cylinders 10. The wire type excavating accuracy control device comprises a three-dimensional gyro sensor device that is located near the bearing member 11 and detects the tip position of the excavating and agitating blade shaft 6, a construction control device 22 into which measurement signals for the tip position of the excavating and agitating blade shaft 6, measured by the three-dimensional gyro sensor device, are inputted, and a hydraulic control circuit of the hydraulic cylinder 10 controlled by control signals calculated and processed by the construction control device 22 on the basis of the measurement signals, and is characterized in that the hydraulic cylinders 10 are individually controlled to pull the respective wires or the like 12, to thereby forcibly correct and control the tip position of the excavating and agitating blade shaft 6.

[0016] The invention claimed in claim 2 is the wire type excavating accuracy control device of a soil improving machine according to claim 1, characterized in that the drive shaft 4 is configured as a multi-connecting shaft obtained by successively jointing a plurality of unit shafts, and that a curve is generated in the drive shaft 4 through the use of allowance of a shaft coupling 40 of each joint portion, to thereby make it possible to forcibly correct and control the tip position of the excavating and agitating blade shaft 6.

[0017] The invention claimed in claim 3 is the wire type excavating accuracy control device of a soil improving machine according to either one of claims 1 and 2, characterized in that the bearing member 11 for maintaining constant center distance between drive shafts 4 in a multishaft soil improving machine using a plurality of drive shafts 4 is configured in a pin-joint structure in which bearings for respective drive shafts 4 are roller bearings 11a and are movably jointed with a horizontal pin 11d so as to allow deformation between the bearings in between the adjacent drive shafts 4, and that the plurality of wires or the like 12 that are symmetrically provided to each bearing 11a have lower ends connected to respective brackets 15 protruding from the bearing member 11 in a lateral direction.

[0018] The invention claimed in claim 4 is the wire type excavating accuracy control device of a soil improving machine according to claim 1, characterized in that the hydraulic control circuit of the hydraulic cylinder 10 comprises a high pressure control circuit 30 and a low pressure control circuit 31 juxtaposed with each other, supplies high-pressure oil from the high pressure control circuit 30 to the hydraulic cylinder 10 to pull the wires or the like 12, and supplies low-pressure oil from the low pressure control circuit 31 to pull in the slack of the wires or the like 12.

Brief Description of the Drawings

[0019]

FIG. 1 is an elevation view of a soil improving machine according to the present invention;
FIGS. 2A and 2B are front and side views, on an enlarged scale, showing a digging drive and the periphery thereof;
FIG. 3 is a front view, on an enlarged scale, showing a bearing member located under a drive shaft and a periphery thereof;
FIG. 4 is a sectional view of the bearing member, viewed in a planar direction;
FIG. 5 is a view showing a control circuit of a hydraulic cylinder; and
FIGS. 6A and 6B are explanatory views showing diagrammatically a configuration and curving state of the drive shaft.

Best Mode of Carrying out the Invention

[0020] An embodiment of a wire type excavating accuracy control device of a soil improving machine according to the invention claimed in claims 1 through 4 will be explained below with reference to FIGS. 1 through 6.

[0021] As stated above, a soil improving machine of FIG. 1 comprises a wire type excavating accuracy control device, including a plurality of wires 12 (PC steel rods, PC steel wires or the like may be utilized instead, and hereinafter, they are generically referred to as "wires or the like"), arranged around a drive shaft 4 and coupled between hydraulic cylinders 10 suspended under a digging drive 2 for rotating-driving the drive shaft 4 to propel the drive shaft 4 along a rail 3 of a leader 1 perpendicularly downward, and a bearing member 11 disposed in a portion directly above an excavating and agitating blade shaft 6 connected to a lower end of the drive shaft 4, to thereby forcibly correct and control a tip position of the excavating and agitating blade shaft 6 by pulling the wires 12 individually by means of the hydraulic cylinders 10.

[0022] As is clear from FIGS. 2A and 2B showing a

digging drive 2 on an enlarged scale, this is an embodiment of a two-axis soil improving machine. A locational relation between two excavating and agitating blade shafts 6, 6 connected to lower ends of two drive shafts 4, 4 and the plurality of wires 12 ... is as exemplified in FIGS. 3 and 4 showing an arrangement in which a total of 6 wires 12 ... encircle the two drive shafts 4, 4.

[0023] FIG. 2 shows a configuration in which upper ends of the six wires 12 ... are connected to output shafts of the hydraulic cylinders 10 through coupling members 13 of a pin-joint type so as to link one wire with one cylinder. The body of each hydraulic cylinder 10 has an upper end portion that is freely coupled to a bracket prepared in a lower base portion of the digging drive 2 also through a pin joint 14.

[0024] The six wires 12 ... have lower ends joined to respective brackets 15 protruding from the bearing member 11 in a lateral direction such that length thereof can be adjusted by respective screw-operated coupling members 16, as illustrated in FIG. 3 on an enlarged scale. The coupling members 16 are covered with respective protection covers 17 for fear that they will be defaced by earth and sand. The length of each wire 12 is adjusted such that the bearing member 11 retains a level posture in a state where the hydraulic cylinders 10 are beforehand extended at maximum stroke.

[0025] Applied as bearings in the bearing member 11 maintaining the two drive shafts 4, 4 at a constant center distance are roller bearings 11a, which rotatably support the drive shafts 4 with low friction. The roller bearings 11a possesses an advantage of having sufficient rigidity to forcibly correct the tip position of the excavating and agitating blade shaft 6 by pulling the bearing member 11 through the wire control. A concrete configuration of the roller bearings 11a, which is preferably employed, is one in which the drive shafts 4 are rotatably supported by roller bearings of an angular type, as shown in FIG. 5 of Unexamined Japanese Patent Publication No. 2001-234527, or the like.

[0026] Because of the configuration, which easily allows lateral deformation between the adjacent drive shafts 4, 4 while maintaining not only the two drive shafts 4, 4 but also the two excavating and agitating blade shafts 6, 6 at the constant center distance, the two roller bearings 11a are movably constructed as a pin-joint structure in which brackets 11b extending in parallel from outer surfaces thereof in a lateral direction and both ends of a hinge member 11c located at a middle position are put together, thereby being coupled to each other by piercing two pins 11d therethrough in the lateral direction.

[0027] The lower ends of the six wires 12 ... are, as illustrated in FIG. 4, joined to their respective brackets 15 arranged at regular intervals in positions located in three right-angled directions, the positions being included in a semicircle that is approximately half of the outer side of each of the two roller bearings 11a, 11a, so that a moment operates with lateral arms protruded, (the aforementioned is the invention claimed in claim 3).

[0028] Therefore, depending on which of the six wires 12 ... are pulled hard by the hydraulic cylinders 10, the tip positions of not only the two drive shafts 4, 4, but the two excavating and agitating blade shafts 6, 6 as well, can be forcibly and accurately corrected and controlled without difficulty in either an anteroposterior direction (the Y direction in FIG. 4) or lateral direction (the X direction in FIG. 4).

[0029] As a real-time measurement means for the tip positions of not only the two drive shafts 4, 4, but the two excavating and agitating blade shafts 6, 6, a three-dimensional gyro sensor device is installed in a sensor case 20 located near the bearing member 11, as more specifically shown in FIG. 3, halfway between the two drive shafts 4, 4, by being fixed onto the outer surface of the right bearing 11a, facing into the drawing, the device being composed by combining a clinometer of X, Y two-dimensional directions and a gyro sensor, as disclosed in, for example, Japanese Patent No. 3156049, although a detailed illustration is omitted.

[0030] With the three-dimensional gyro sensor device, during the constructing process of the soil improving construction using the soil improving machine, the tip position of the excavating and agitating blade shaft 6 is accurately detected in real time. Furthermore, a locus and horizontal cross sectional shape of the constructed piles in soil columns are stored as data. Measurement signals according to the three-dimensional gyro sensor device are transmitted to an above-ground construction control device 22 (FIG. 5) through signal wires in a signal wire protection pipe 21 connected to the sensor case 20.

[0031] FIG. 5 shows a hydraulic control circuit for automatically controlling the hydraulic cylinder 10 in real time, based on a measurement value of the three-dimensional gyro sensor device. The circuit has a configuration in which a high-pressure control circuit 30 and a low-pressure control circuit 31 juxtaposed with each other are provided to one hydraulic cylinder 10, and the wire 12 is pulled by way of the high-pressure control circuit 30.

[0032] When measurement signals 23 measured by the three-dimensional gyro sensor device located in the underground sensor case are inputted into the construction control device 22 (which is a common personal computer), the signals 23 are subjected to comparative calculation with pressure signals 25 inputted from a pressure converter 24 that is attached to each hydraulic cylinder 10. The result of the comparative calculation is sent to an operating panel 27 for a hydraulic cylinder, and is simultaneously displayed on the screen of a monitor 26 for an operator in real time.

[0033] In the operating panel 27 for a hydraulic cylinder, based on the result of the comparative calculation, control signals with respect to the high pressure control circuits 30 and the low pressure control circuits 31 of the six hydraulic cylinders 10 ... are generated and trans-

mitted. In other words, an electromagnetic relief valve 32, a shut-off valve 33 and an electromagnetic switch valve 34 of the high pressure control circuit 30 and an electromagnetic switch valve 35 of the low pressure control circuit 31 are each controlled.

[0034] For instance, when the wire 12 is pulled by the hydraulic cylinder 10, the high pressure control circuit 30 is opened up to supply high-pressure oil into a piston lower chamber of the hydraulic cylinder 10, to thereby cause contraction, in a state where the shut-off valve 33 is free. To create a retention state, the shut-off valve 33 is closed to maintain a constant stroke of the hydraulic cylinder 10 even if an external force is applied thereto. To create a neutral state in which the slack of the wire 12 is taken up, the low pressure control circuit 31 is opened up with the shut-off valve 33 made free to supply low-pressure oil into the piston lower chamber of the hydraulic cylinder 10, to thereby retain a state of tension by pulling gently so as not to slacken the wire 12, (the invention claimed in claim 4).

[0035] In effect, in FIG. 4, if the wires 12 denoted by "a" and "b" or "e" and "d" are pulled by the corresponding hydraulic cylinders 10, it is possible to make a position correction in the anteroposterior direction. Pulling the wires 12 represented by "b," "c" and "d" or "a," "f" and "e" allows a position correction in the lateral (right and left) direction. At that time, the hydraulic cylinders 10 of the other wires 12 are kept in a retention state to be applied with a reactive force for the position correction. Additionally, through a variety of combinations, it is possible to forcibly and quickly implement the control required for the position correction of the tip positions of not only the two drive shafts 4, 4, but the two excavating and agitating blade shafts 6, 6 as well, with accuracy.

[0036] In the event the tip position of the excavating and agitating blade shaft 6 is out of or likely to be out of a planned position, (position of specified lap length), immediate correction and control are carried out to bring the tip position to the planned position by way of the hydraulic cylinders 10 and the wires 12. Consequently, it is not necessary to perform the construction with extra lap length ready beforehand.

[0037] The position correction of the tip positions of not only the two drive shafts 4, 4, but the two excavating and agitating blade shafts 6, 6, is controlled by pulling the wires 12 individually by means of the hydraulic cylinders 10. However, adjustment of the pulling force (amount of hydraulic pressure supplied to the hydraulic cylinders 10) varies depending on conditions, such as texture and property of excavation soil, greatness of lap length of the piles in soil columns, etc. Therefore, preferably, test construction is first carried out to collect information necessary for practice, and the construction is carried out after determining the amount of the controllable pulling force and that of the hydraulic pressure, based on such information.

[0038] Along with the progress of the soil improving construction, various data required for the construction control of the piles in soil columns are collected, as disclosed in Japanese Patent No. 3156049, and an analyzed value is inputted and stored in the construction control device 22, to thereby calculate the pulling force required for the correction and control of positions. Then, preferably, after the result is checked with the position detection data and plan to be reflected in automatic hydraulic control, a step for providing feedback of the result to the tip position control is repeated.

[0039] At the time of lateral position correction that pulls the wires 12 denoted by "b," "c" and "d" or "a," "f" and "e," as illustrated in FIG. 3, the pin-joint structure, in which the two roller bearings 11a, 11a as bearing components of the bearing member 11 are coupled with the pins 11d, makes it possible to carry out the position correction with high response without generating useless resistance.

[0040] As a device for enabling position correction with superior response, the drive shaft 4 of the soil improving machine according to the present invention is constructed as a multi-connecting shaft obtained by continuously joining a plurality of unit shafts to one another with the shaft couplings 40 as illustrated in FIGS. 6A and 6B. Through the use of allowance produced in the shaft coupling 40 of each joint portion, a curve is smoothly made in the drive shaft 4 as far as the location of the bearing member 11, to thereby make it possible to forcibly correct the tip position of the excavating and agitating blade shaft 6, (the invention claimed in claim 2).

[0041] There is a wide variety of unit shafts of the excavating shaft 4, including general shafts with a length falling in a range of from 5 m to 10 m, and adjustment shafts from 1 m to 4 m. Allowance of the shaft coupling 40 is usually about 2.6×10^{-2} rad. when the coupling is brand-new, and gradually grows according to the frequency of usage. For this reason, if the number of the shaft couplings 40 is properly designed, the flexible drive shaft 4 can be obtained without difficulty, and the position correction then becomes simple, thereby being much more advantageous than a single-operating drive shaft in terms of control. There is no fear of adverse effects of such allowance since applying a proper pulling force to the drive shaft 4 in a balanced manner using the wire 12 has the effect of improving rigidity of the drive shaft 4.

[0042] As illustrated in FIGS. 6A and 6B, when the wires 12 are pulled to create a curve in the drive shaft 4 and to correct and control the tip position of the excavating and agitating blade shaft 6, a fixing point of the drive shaft 4 is a lower steady brace 37. Therefore, it is desirable that the lower steady brace 37 be embodied in a configuration in which a roller type guide mechanism using a roller for rotatably supporting the drive shaft 4 is employed, for instance as illustrated in FIG. 2A of Unexamined Japanese Patent Publication No. 2001-234527, for example. A middle steady brace 38 is also configured in the same manner.

Industrial Applicability

[0043] The wire type excavating accuracy control device of a soil improving machine according to the invention claimed in claims 1 through 4 is capable of measuring the tip position of the excavating and agitating blade shaft by using a three-dimensional gyro sensor device, detecting the locus of the improving pile previously constructed and subsequently the tip position of the excavating shaft of the improving pile to be lapped over, in real time, to make comparative calculation, and in the event the tendency to deviate from the planned position is observed, capable of accurately making immediate directional correction of the tip position under highly responsive control, thereby carrying out control of plumbing accuracy for securing the exact lapped amounts required at the construction site.

[0044] As a consequence, the present invention makes it possible to perform easily construction in which the specified lapped amounts between piles in soil columns are secured with accuracy. This enables efficient construction with the lap length required by design. As a result, it is possible to make the pitch of the soil improving piles proper, to thereby perform efficient and economical soil improving construction.

Claims

1. A wire type excavating accuracy control device of a soil improving machine consisting of a plurality of wires or the like (12) arranged around a drive shaft (4) and coupled between hydraulic cylinders (10) suspended under a digging drive (2) for rotating-driving said drive shaft (4) of said soil improving machine to propel said drive shaft (4) along a leader (1) perpendicularly downward and a bearing member (11) disposed in a portion directly above an excavating and agitating blade shaft (6) connected to a lower end of said drive shaft (4), and correcting and controlling a tip position of said excavating and agitating blade shaft (6) by pulling said wires or the like (12) individually by means of said hydraulic cylinders (10), said wire type excavating accuracy control device comprising:

   a three-dimensional gyro sensor device that is located near said bearing member (11) and detects said tip position of said excavating and agitating blade shaft (6);
   a construction control device (22) into which measurement signals (23) for said tip position of said excavating and agitating blade shaft (6), measured by said three-dimensional gyro sensor device, are inputted; and
   a hydraulic control circuit of said hydraulic cylinder (10) controlled by control signals calculated and processed by said construction control device (22) based on said measurement signals (23), wherein:

      said applicable hydraulic cylinders (10) are individually controlled to pull said respective wires or the like (12), thereby forcibly to correct and control said tip position of said excavating and agitating blade shaft (6).

2. The wire type excavating accuracy control device of a soil improving machine according to claim 1, wherein said drive shaft (4) is configured as a multi-connecting shaft obtained by successively joining a plurality of unit shafts to one another, and wherein a curve is generated in said drive shaft (4) through use of allowance of a shaft coupling (40) of each joint portion, thereby making it possible to correct and control forcibly said tip position of said excavating and agitating blade shaft (6).

3. The wire type excavating accuracy control device of a soil improving machine according to either one of claims 1 and 2, wherein said bearing member (11) for maintaining constant center distance between drive shafts (4) in a multishaft soil improving machine using a plurality of drive shafts (4) is configured in a pin-joint structure in which bearings for respective drive shafts (4) are roller bearings (11a) and are movably joined with a horizontal pin (11d) so as to allow deformation between the bearings in between said adjacent drive shafts (4), and wherein said plurality of wires or the like (12) that are symmetrically provided to each of said bearings (11a) have lower ends connected to respective brackets (15) protruding from said bearing member (11) in a lateral direction.

4. The wire type excavating accuracy control device of a soil improving machine according to claim 1, wherein said hydraulic control circuit of said hydraulic cylinder (10) comprises a high pressure control circuit (30) and a low pressure control circuit (31) juxtaposed with each other, supplies high-pressure oil of said high pressure control circuit (30) to said hydraulic cylinder (10) to pull said wires or the like (12), and supplies low-pressure oil of said low pressure control circuit (31) to pull in the slack of said wires or the like (12).

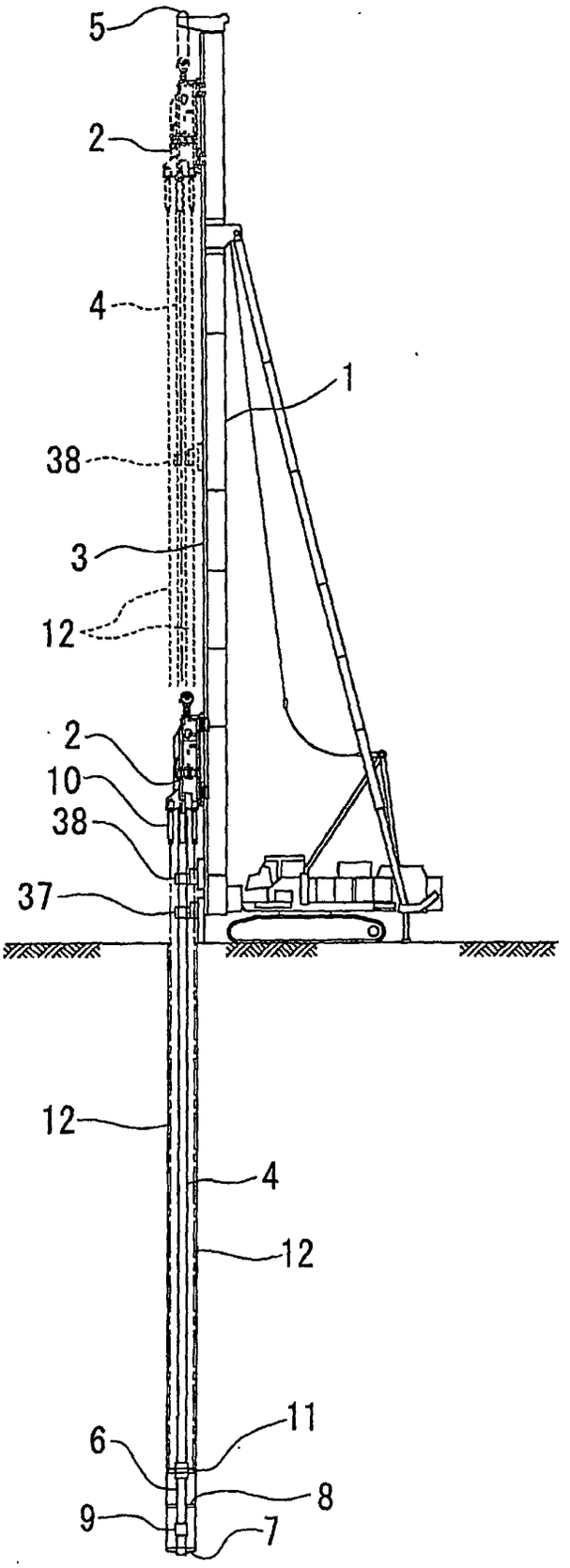

FIG. 1

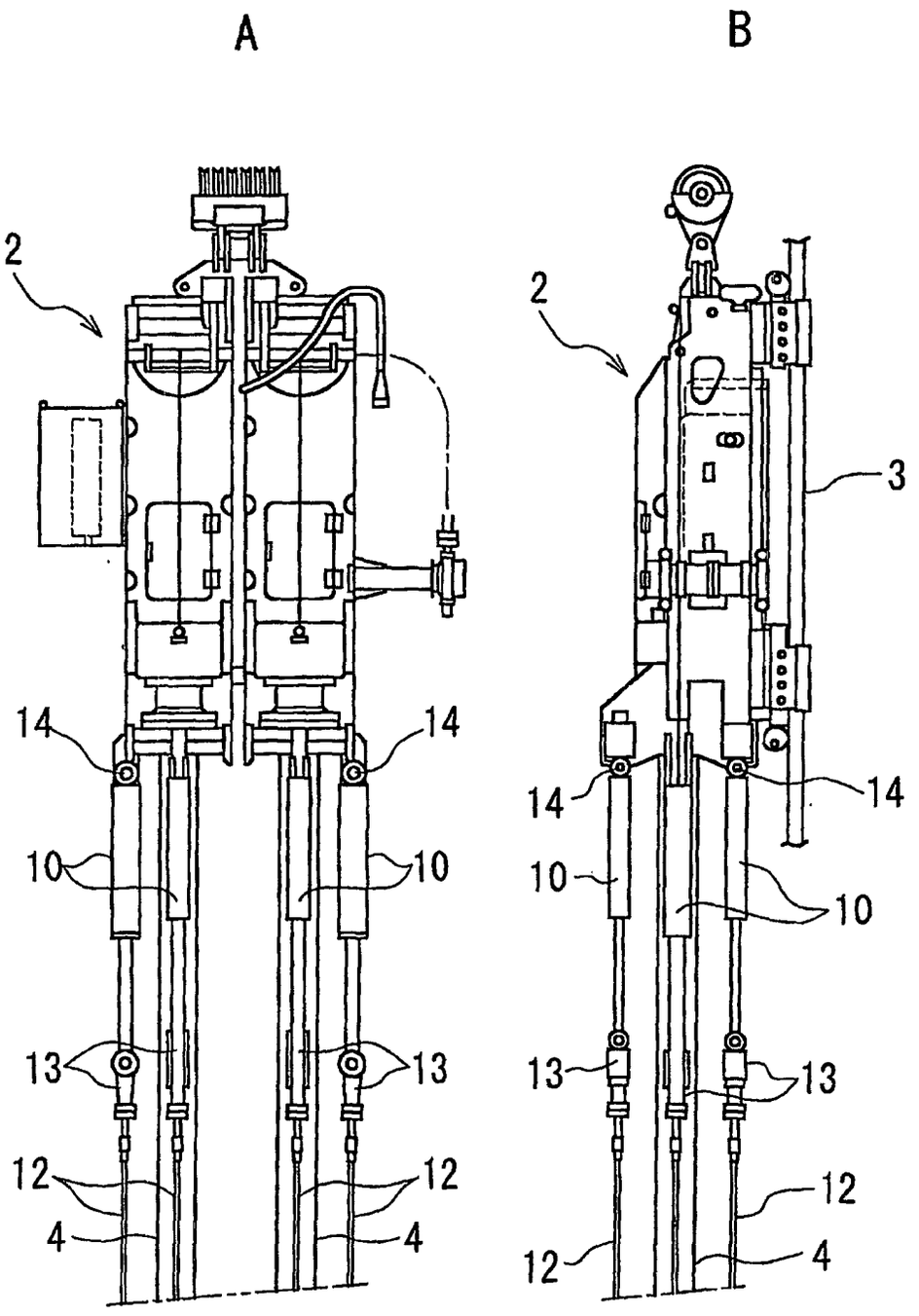

FIG. 2

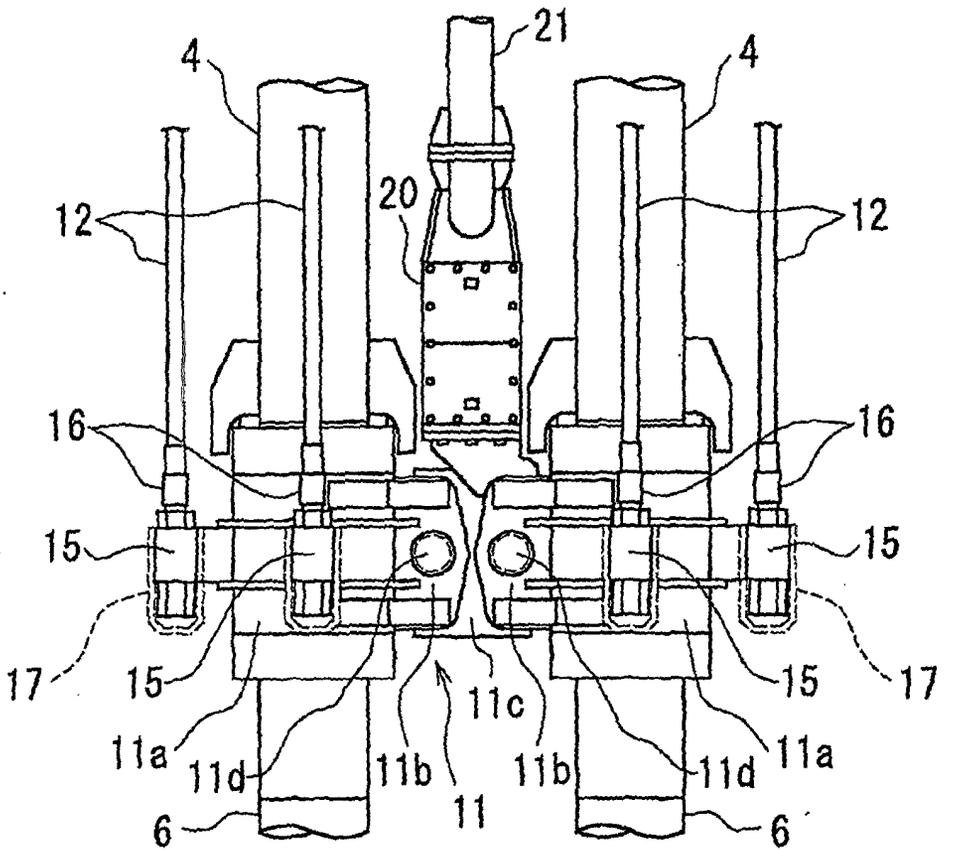
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FIG. 3

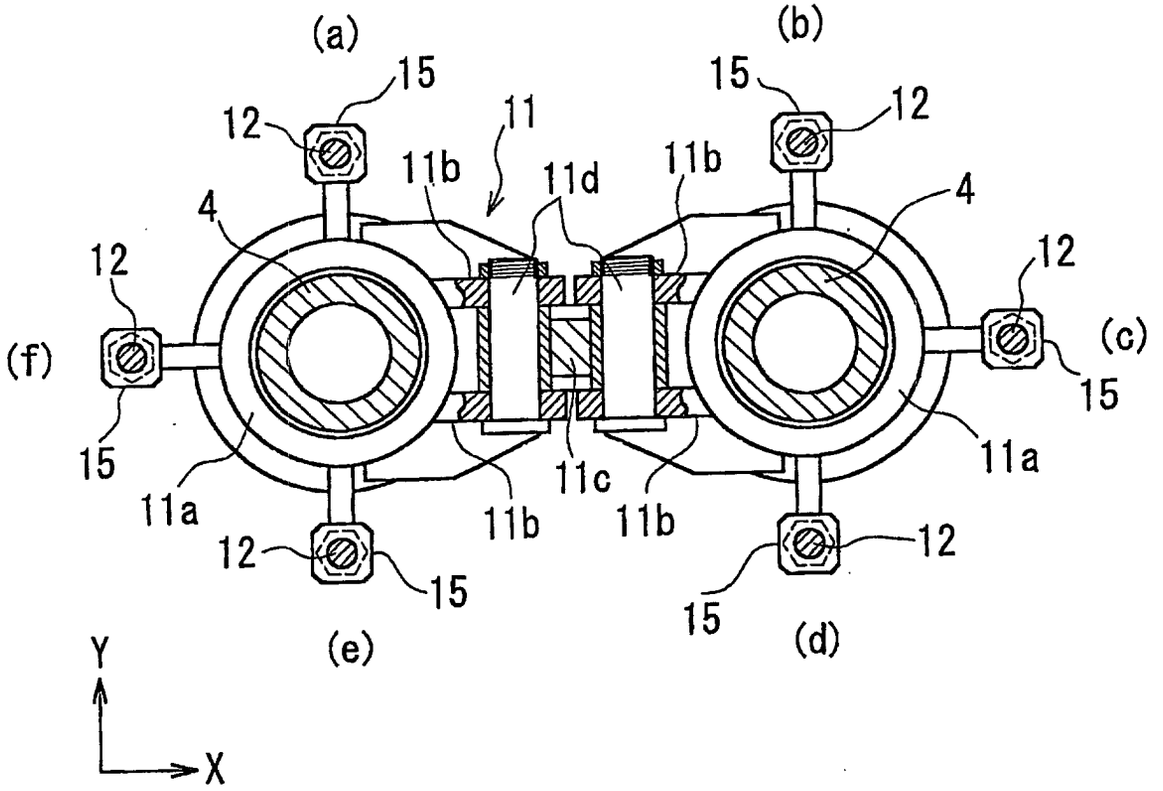

FIG. 4

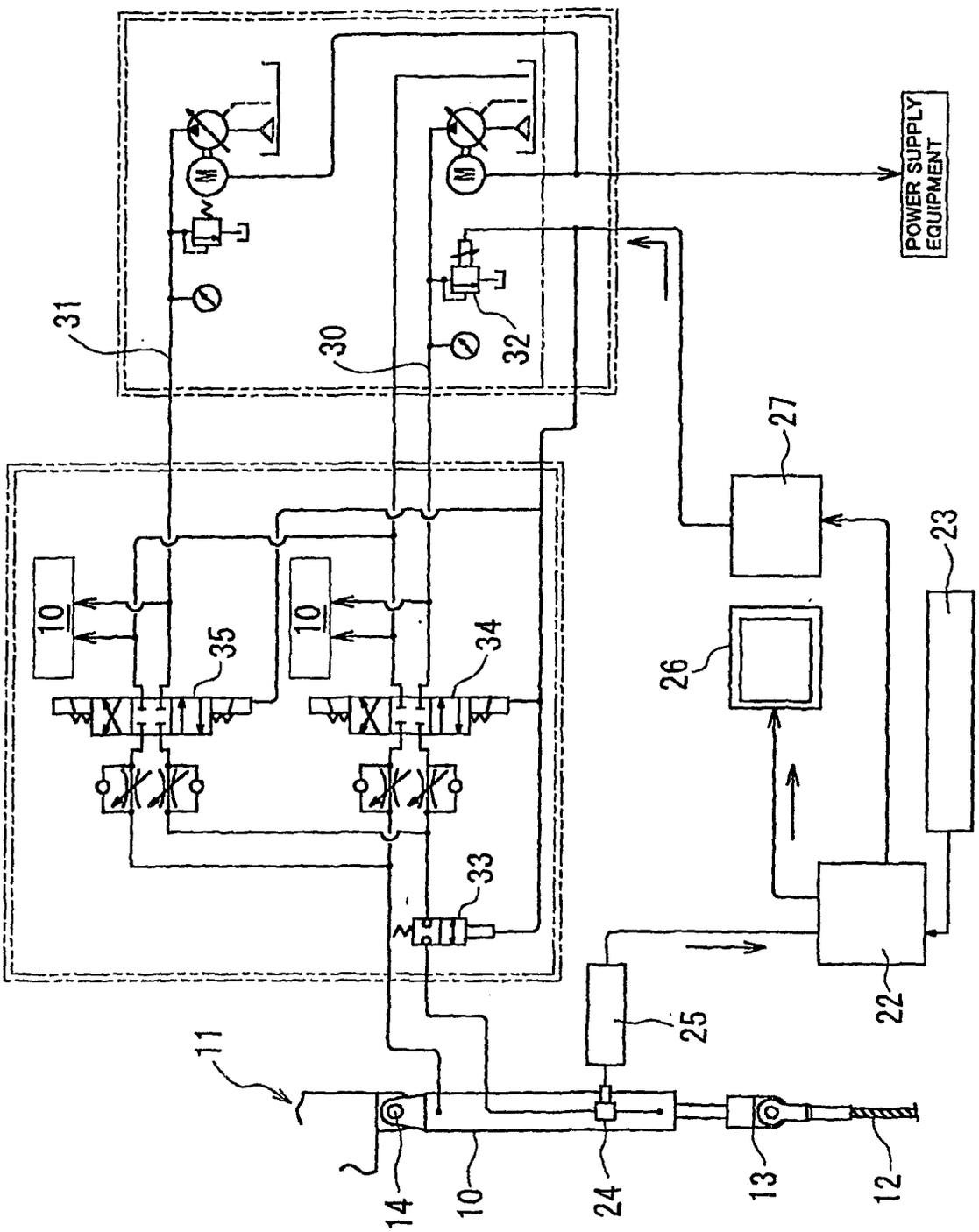
POWER SUPPLY EQUIPMENT
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FIG. 5

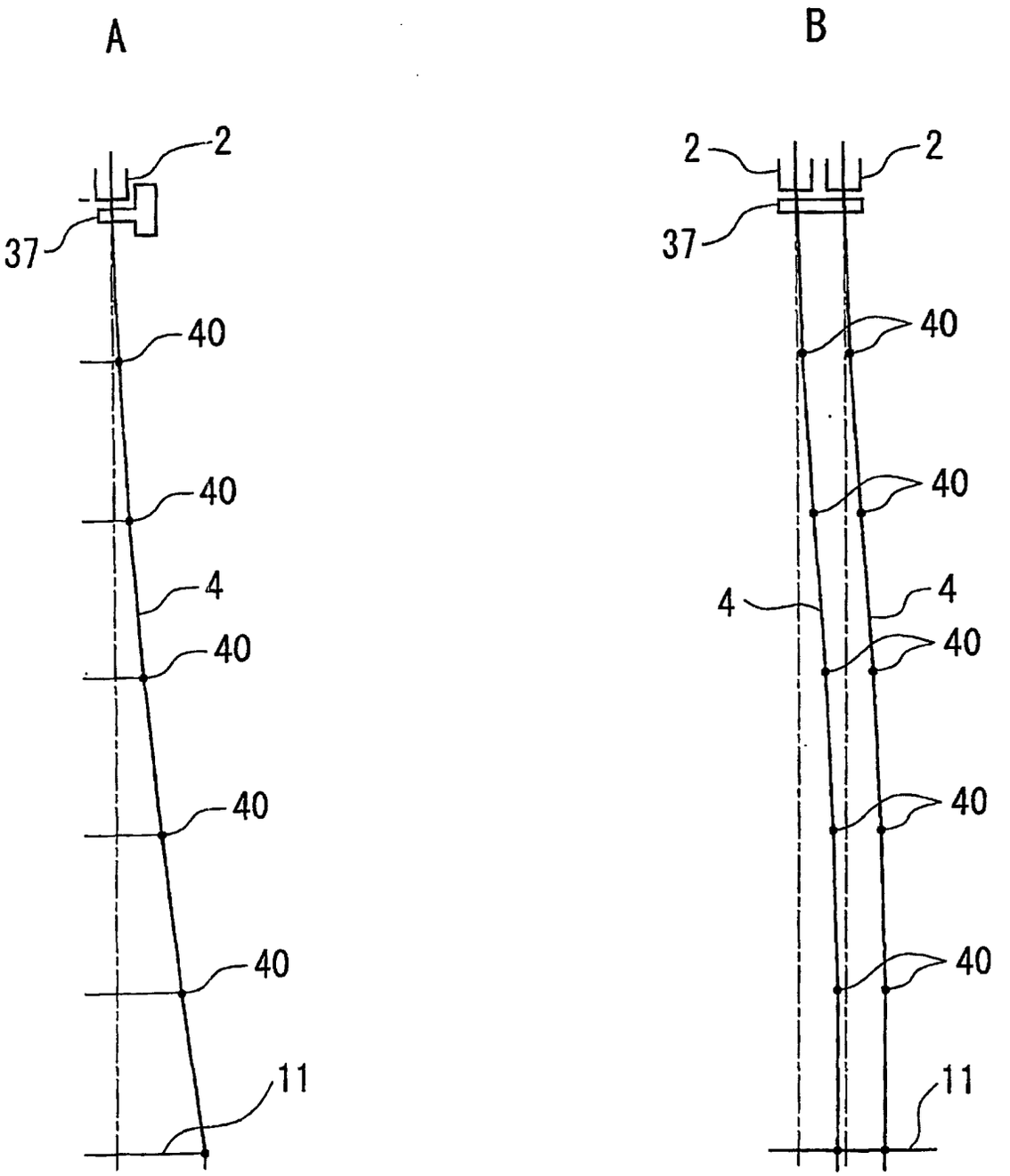

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/01256

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] E02D3/12, E02F5/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] E02D3/12, E02F5/02

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

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2003
Kokai Jitsuyo Shinan Koho	1971-2003	Jitsuyo Shinan Toroku Koho	1996-2003

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2000-38738 A (Keisuke HIOKI), 08 February, 2000 (08.02.00), Full text; all drawings (Family: none)	1-3 4
Y A	JP 6-26047 A (Kobe Steel, Ltd.), 01 February, 1994 (01.02.94), Full text; all drawings (Family: none)	1-3 4
Y A	JP 8-246460 A (Raito Kogyo Co., Ltd.), 24 September, 1996 (24.09.96), Full text; all drawings (Family: none)	2 4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May, 2003 (15.05.03)	03 June, 2003 (03.06.03)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/01256

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2001-3383 A (Nishimatsu Construction Co., Ltd.), 09 January, 2001 (09.01.01), Full text; all drawings (Family: none)	3 4
A	JP 10-299028 A (Takenaka Corp.), 10 November, 1998 (10.11.98), Full text; all drawings (Family: none)	1-4
A	JP 7-19863 A (Hazama Corp.), 20 January, 1995 (20.01.95), Full text; all drawings (Family: none)	1-4
A	JP 7-103758 A (Kumagai Gumi Co., Ltd.), 18 April, 1995 (18.04.95), Full text; all drawings (Family: none)	1-4

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