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(54) **WIRE SAW EXCAVATOR, CUT-OFF WALL OR LANDSLIDE PROTECTION CONSTRUCTION CONSTRUCTED THEREBY AND CONSTRUCTION METHOD THEREOF.**

(57) In the ground (T), preceding holes (3) are dug and also a portion between adjoining preceding holes (3) is excavated by use of a wire saw device (9) to thereby form a sheet insertion groove (4), into which a cut-off sheet (5) is inserted, while, engageable portions (7) provided at opposite end portions in the widthwise direction of the cut-off sheet (5) are positioned within the preceding hole (3), whereby the cut-off sheet (5) is pulled into the sheet insertion groove (4). Bentonite mortar is filled in the preceding hole (3) and the sheet insertion groove (4), which are brought into a water-tight state, to thereby form a cut-on sheet wall (I). The ground (T) is excavated by use of the wire saw device (9) and a sheet setting device (10) to thereby form the sheet insertion groove (4), while the cut-off sheet (5) is pulled into the sheet insertion groove (4), so that the working efficiency for constructing the cut-off sheet wall (1) is improved, and moreover, the insertion of the cut-off sheet (5) into the sheet insertion groove (4) can be easily and accurately performed, to thereby improve the con-

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struction accuracy.

FIG.1(A)

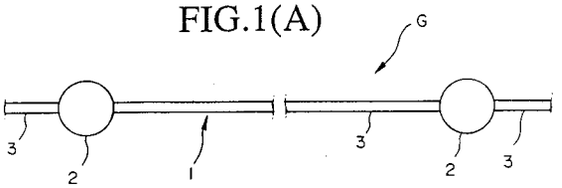
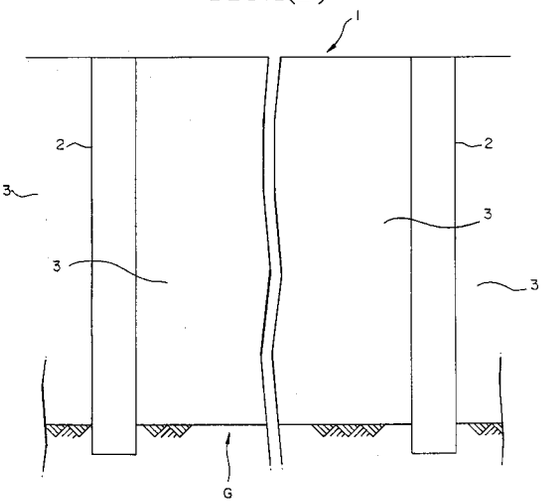


FIG.1(B)



Technical Field

The present invention relates to a wire saw excavator for excavating the ground, to a wall forming a water barrier and a method of construction of the wall forming a water barrier using the wire saw excavator, and to a landslide protection wall and a method of constructing the landslide protection wall using the wire saw excavator.

Background of the Invention

(1) In the case of building an underground structure, it is sometimes necessary to provide a barrier so that the groundwater cannot enter into the excavation area.

For example, as a means for preventing water seepage, a method using simply steel sheet-piles, a method using a diaphragm wall and the like, are proposed and used.

However, the method which includes or uses only steel sheet piles, cannot be adapted at great depths. On the other hand, the method using a diaphragm wall can prevent water seepage in an area of great depth. However, the excavation cost becomes high, because an excavation at great depths requires that the wall forming the water barrier be relatively thick. For instance, in an area that is 100 m deep, a thickness of at least 1000 mm is required.

Therefore, the present invention, provides a method for building the wall forming a water barrier, which is more economical, compared with the prior art [for example, Japanese Patent Application No. (TOKUGANHEI) 1-231227], in an excavation area of great depth.

This method comprises: forming a ditch in order to excavate the ground by a wire saw; and providing a sheet forming a water barrier, in the ditch.

However, in this method, the sheet forming a water barrier may be broken by conglomerates and the like in the ground, when it is being withdrawn. In this case, there are some problems: for instance, lowering the performance of the sheet forming a water barrier and the like.

(2) On the other hand, many kinds of wire saw excavators for building a wall forming a water barrier, have been provided.

Representative examples of these are described below.

An excavator comprising:

a diamond tipped saw provided close to a first guide hole and a second guide hole which are provided in the ground at a specified distance in the horizontal plane;

the diamond tipped saw held tightly between the first guide hole and the second guide hole so as to excavate the ground by running therebetween and, thereby, forming a ditch;

trusses provided between the first guide hole and the second guide hole, respectively, in the ground after the ditch is formed by excavating;

a sheet forming the water barrier, provided in the ditch; and

solidification material, for preventing water seepage, provided between the sides of the ditch and the wall forming the water barrier [Japanese Patent Application Laid Open No. (TOKUKAIHEI) 2-171412].

An excavator comprising:

two diamond tipped saws provided close to the first guide hole and the second guide hole which are provided in the ground at a specified distance in the horizontal plane;

the diamond tipped saw held tightly between the first guide hole and the second guide hole so as to excavate the ground by running therebetween, thereby forming a ditch;

trusses provided, respectively, between the first guide hole and the second guide hole, in the ground after the ditch is formed by excavation;

a sheet forming a water barrier, provided in the ditch; and

solidification material for prevention of water seepage, provided between the sides of the ditch and the wall forming a water barrier [Japanese Patent Application Laid Open No. (TOKUKAIHEI) 2-171415].

An excavator comprising:

a strut bar provided above guide holes in the ground, at a specified distance, in the horizontal plane;

main piles having upper pulleys and lower pulleys, with the upper set of pulleys having an outer pulley and inner pulley disposed at the upper portion of each pile, and the lower set of pulleys having an outer pulley and inner pulley which are disposed at the lower portion of each pile, and have removable connection members for connecting one main pile and the adjacent main piles, with the main piles comprising plural main piles connected by a removable connection member;

the first guide piles and the second guide piles being provided at both ends of the strut bar;

a driving apparatus having a driving pulley; and

a diamond tipped saw connected in turn, as follows: from the driving pulley to the outer pulley of the upper set of pulleys of the first guide pile, therefrom to the outer pulley of the

upper set of pulleys of the second guide pile, therefrom to the outer pulley of the lower set of pulleys of the second guide pile, therefrom to the inner pulley of the lower set of pulleys of the first guide pile, therefrom to the inner pulley of the upper set of pulleys of the first guide pile in turn, and thereby the diamond tipped saw is an endless body [Japanese Patent Application Laid Open No. (TOKUKAIHEI) 2 – 171423].

An excavator comprising:

two guide struts hung by a crane and the like, which are entered, respectively, into the adjacent two guide holes provided in the ground;

at least one pivotal pulley provided at the lower portion of the guide hole;

an endless cutter held tightly at a specified point of the guide strut and on the ground in accordance with the construction of the wall forming the water barrier;

a driving mechanism (for example a motor and the like) for making the endless cutter run [Japanese Patent Application Laid Open No. (TOKUKAIHEI) 2 – 178418].

The excavator shown in an application [Japanese Patent Application No. (TOKUGANHEI) 1 – 231227] of the prior art, as shown in Fig. 10, comprising:

H – section steel guide 18 disposed in each of the two guide holes 2 which are excavated in the ground, at an appropriate depth;

a movable pulley 17, which can move up and down, provided, respectively, at each H – section steel 18;

a fixed pivotal pulley (P) provided at the lower portion of the H – section steel;

a wire saw 11 held tightly between the movable pulley 17 and the fixed pulley (P); and

a driving apparatus 14 for making the wire saw 11 run.

The movable pulley 17 can move downward because the driving apparatus 14 may be transferred in the cross direction.

However, the prior art, as described above, has the following problems:

Excavating with the above excavator and entering the sheet forming the water barrier into the ditch excavated by the above excavator, cannot be performed simultaneously.

In ground of uneven hardness, the deviation in the dip of the wire saw is large, causing the wire saw to move off course sideways. Therefore, the wire saw deviates from the course of the pulley, and a deviation in the course of excavation occurs. Accordingly, the excavator, as described above, cannot accurately excavate under these conditions.

It is very difficult to control the movable pulleys because friction between the pulleys and the H – section steel, ground pressure and the like are not uniform. Therefore, it is not easy to control the height of the movable pulleys in the first guide hole and in the second guide hole. In addition, it is impossible to pull up the wire saw for inspection, maintenance, and the like.

(3) On the other hand, during excavation it is also necessary to construct walls for protection from landslides. The method of construction of a landslide protection wall with the wire saw excavator described above, is comprised of the following steps:

driving the steel material such as H – section steel into the ground; and

providing a horizontal sheet pile between the steel material.

The depth of the slide protection wall according to the method of construction described above, is comparatively shallow. In the case where the excavation is in close proximity to a building, this method of construction is particularly easy to adapt and is an economical method for general utility.

However, because the ability of the slide protection wall to prevent water seepage is low, if ground water leaks or seeps through to the inside of the body of a river levee, sea levee, dam levee and the like, which goes into the side excavator, it interferes with the work thereof.

With respect to the above problem, a wall forming a water barrier which is impermeable and can function continuously in a levee body or in a base in the ground, is proposed. This wall for forming a water barrier, is made from concrete, asphalt, steel pile, impermeable silt, impermeable sheet, and the like.

In the case of constructing the above-mentioned wall for forming a water barrier, for instance, in the case of constructing a levee body using impermeable materials,

from the surface of the ground, a ditch is excavated for the impermeable layer; each sheet is provided in the ditch so as to overlap on the sides; and each overlapping portion of each side, and the deepest portion of each sheet are disposed in a manner so that it prevents water seepage.

In a conventional construction for preventing water seepage using sheets,

each joint portion of the adjacent sheets is overlapping;

the ditch around each joint portion is enlarged;

the enlarged portion of the ditch is filled with hardener such as mortar; and

packing material is provided in each over-

lap, on each side of the deepest section, of each sheet

whereby continuous prevention of water seepage is performed.

However, the wall forming a water barrier, is constructed by using sheets and therefore, the method thereof has the following problems:

Namely, at joint portions of the sheets, it is difficult to accurately overlap in proportion with the depth of the ditch when the sheets are large. In this instance, the end portions (i.e. the deepest portion) of the sheets are turned up.

Disclosure of the Invention

(1)' In consideration of the above-described problem (1), it is an objective of the present invention to provide a method of construction of the wall forming a water barrier in which the ability of the wall to prevent water seepage is higher than in the prior art.

In order to satisfy this objective, the invention in accordance with claim 3, provides a method of construction of the wall forming a water barrier, which is constructed by using a wire saw excavator, and is comprised of the following steps:

excavating the ground to provide two guide holes;

excavating the ground for forming a ditch between adjacent guide holes by operation of the wire saw;

placing impermeable material in the adjacent two guide holes and the ditch; and

making the wire saw run in order to place the impermeable material into the ditch and the guide holes.

The problem with the prior art method using the wire saw excavator to construct the wall forming the water barrier is that the sheet for prevention of water seepage was broken because other impervious materials were used instead of the sheet. Accordingly, the wall forming the water barrier of the present invention in accordance with claim 3, can greatly improve the prevention of water seepage, in comparison to the prior art. Accordingly, the wall having the improved ability to prevent water seepage is constructed by the invention in accordance with claim 3.

Impervious materials, preferably materials of the present invention, such as a mixture of bentonite slurry and self-hardening slurry comprising sodium silicate and the cement as the primary component, mixture of the bentonite slurry and the polyethylene, bentonite slurry and asphalt may be adopted for use in the construction of the wall forming a water barrier. However, only self-hardening slurry can be adopted as the impervious materials. In this case, it is possible to improve the ability of the wall forming the water barrier, to prevent water seepage. The guide may be removed or buried under the ground.

(2)' In consideration of the above-described problem (2), it is an objective of the invention in accordance with claim 1 and in accordance with claim 2, to provide a wire saw excavator which can simultaneously excavate the ditch and insert the sheet into the ditch, can be adapted to soft ground, control the height of the moving pulley in the one guide hole and also the height of the pulley in the second guide hole, and maintain the wire saw, the moving pulleys and the like in order to pull them up more easily than in the prior art.

In order to satisfy the objectives stated above, the invention in accordance with claim 1 provides a wire saw excavator for constructing a wall forming a water barrier comprising:

two guides disposed, respectively, in two guide holes in an excavation site, the guide holes extending deeper than the finished depth of the wall to be constructed as a water barrier;

two moving pulleys, disposed in a manner so that one pulley is attached to each guide and is movable along the guide;

two traveling means for moving the pulleys up and down along the guides;

a wire saw for excavating a ditch between the two guide holes which is held tightly and is able to pass at least once between the two moving pulleys;

a driving means for driving the wire saw; and

a grasping means for grasping a sheet comprising the wall forming a water barrier.

In order to satisfy the objectives described above, the invention in accordance with claim 2 provides a wire saw excavator comprising:

a driving carriage provided at a guide column in the ground so as to be able to travel up and down along the guide column;

a control carriage provided at the second guide column so as to be able to travel up and down along an adjacent guide column in the ground; and

a wire saw provided between the guide carriage and the control carriage for excavating the ground by traveling along the course of the pulleys.

Since the wire saw excavator is constructed as described above, the wire saw excavator has functions and advantages distinct from the prior art and are describe hereinbelow.

Because the grasper in accordance with claim 1 and in accordance with claim 2, grasps the sheet comprising the wall forming the water barrier, and this wall is pulled into the ditch along with the downward movement of the moving pulleys, the wire saw excavator in accordance with claim 1 can simultaneously excavate the ditch and pull the sheet into the ditch. Because the pulleys move up and down in the guide holes, the elevator for elevating the moving pulleys can easily control the position of the moving pulleys in each guide hole, and therefore making it easy to pull up the wire saw, the moving pulleys and the like for inspection and maintenance during excavation. Therefore, relative to the prior art, the duration of the excavation is shortened. Furthermore, since the invention can prevent the sideways deviation of the wire saw, the wire saw excavator can be adapted for use in soft ground.

By means of the wire saw excavator in accordance with claim 2, it is possible to easily form the ditch because the drive carriage and the control carriage go down along the guide column during operation. Moreover, because the excavating portions are provided at the drive carriage and the control carriage, and because the wire saw is held tightly between the excavating portions, the excavating portion and the wire saw go up and down along with the upward and downward movements of the drive carriage and the control carriage. Accordingly, the wire saw excavator in accordance with claim 2, differs from the prior art in that no part of the wire saw remains above ground. In the case of constructing a large deep ditch, it is not necessary that the wire be exceedingly long; the ditch can be formed by excavating with the wire saw which has a constant and comparatively short length. Therefore, the wire saw excavator in accordance with claim 2, is used especially in the case of excavating a ditch of great depth. Since the wire saw does not have a part that has to remain above ground, the wire saw excavator is smaller, and the cost thereof is lower compared with the prior art.

(3)' In consideration of the problem (3) described above, it is an objective of the present invention in accordance with claim 4 and in accordance with claim 5, to provide the landslide protection wall and a method of construction thereof, which has a greater ability to prevent water seepage, and can excavate with greater efficiency compared with the prior art.

In order to satisfy these objectives, the present invention in accordance with claim 4, provides a landslide protection wall comprising:

greater than three guide holes in a line, which are disposed in an approximately vertical position in the ground;

a ditch formed by the wire saw excavator;

a sheet wall disposed in the ditch;

soldier beams disposed in each guide hole; and

sheet piles provided between each of the soldier beams;

the impermeable sheet wall between an excavating surface of the ground and the soldier beams in the ditch, with the impermeable sheet having connecting portions at both sides thereof, each connecting portion is disposed in a guide hole, and filler is provided in the ditch.

In order to satisfy the objectives, the invention in accordance with claim 5, provides a construction method of the landslide protection wall comprising:

excavating the ground for the guide holes at the positions at which soldier beams are to be provided;

attaching the lower portions of the sheet to the wire saw excavator, excavating the ditch by the wire saw, and at the same time pulling the impermeable sheet into the ditch;

placing the filler into the guide holes and into the ditch; and

providing the impermeable sheet pile between the soldier beams.

By means of the landslide protection wall and the construction method thereof, and by using the wire saw excavator constructed as described above, ground water is prevented from leaking or seeping from the ground into the excavated portion of the ditch because the side face of the ditch is covered with the sheets which comprises a wall forming a water barrier. Accordingly, when compared with the prior art, the efficiency of the excavation described above is greater.

In addition, because the sheet is drawn into the ditch while excavating the ground, the landslide protection wall is accurately constructed. Accordingly, when compared with the prior art, the efficiency and accuracy of the wall construction is greater.

Furthermore, the accuracy of the wall construction is greater when compared with the prior art, because each engaging portion is engaged with each guide in the guide hole.

Other objectives and features of this invention will be explained in the following description and accompanying drawings.

Brief Description of the Drawings

Fig. 1 (A) is a plane view of a wall forming a water barrier in accordance with the first em-

bodiment of the present invention.
Fig. 1 (B) is an elevational view of the wall forming a water barrier.
Fig. 2 is an elevational view of a the wire saw excavator in accordance with the wall forming a water barrier
Fig. 3 (A) is a plane view of a pulley box in accordance with the wire saw excavator.
Fig. 3 (B) is a side view of a pulley box.
Fig. 4 is a plane view of a wall forming a water barrier in accordance with another embodiment of the present invention.
Fig. 5 is a plane view of a wall forming a water barrier in accordance with yet another embodiment of the present invention.
Fig. 6 is an elevational view of a wire saw excavator of the second embodiment of the present invention.
Fig. 7 is a perspective view of a pulley box of the wire saw excavator.
Figs. 8(A) – 8(D) are process drawings of a pulley box of the wire saw excavator.
Fig. 9 is a perspective view of a grasper of a wire saw excavator.
Fig. 10 is a schematic representation of a wall forming a water barrier of the prior art.
Fig. 11 is a side view of a wire saw excavator of the third embodiment.
Fig. 12 is a perspective view of the driving carriage of the wire saw excavator.
Fig. 13 is a sectional perspective view of the driving carriage.
Fig. 14 is a plane view of the driving carriage of the wire saw excavator.
Fig. 15 is a side view of the driving carriage and a control carriage of the wire saw excavator.
Fig. 16 is a side view of a tension control mechanism provided at the driving carriage when it is not in operation.
Fig. 17 is a side view of a tension control mechanism of the wire provided at the driving carriage during operation.
Fig. 18 is a side view of a guide column of the wire saw excavator.
Fig. 19 is a side view of a ditch excavated by the wire saw excavator.
Fig. 20 is a side view of a sheet pulled into the ditch.
Fig. 21 is a side view of the other tension control mechanism of the third embodiment.
Fig. 22 is a side view of the tension control mechanism of the wire during operation.
Fig. 23 is a perspective view of a landslide protection wall of the fourth embodiment.
Fig. 24 is a perspective view of the plural guide holes of the landslide protection wall.
Fig. 25 is a plane view of the guide hole in the excavation thereof.
Fig. 26 is a perspective view of a sheet of the landslide protection wall pulled into the ditch.
Fig. 27 is a perspective view of a first soldier beam of the landslide protection wall in construction.
Fig. 28 is a perspective view of the second soldier beam of the landslide protection wall.
Fig. 29 is a plane view of a fixed position at the first soldier beam of the guide member of the fifth embodiment.
Fig. 30 is a plane view of a fixed position at the first soldier beam of the guide member of the sixth embodiment.
Fig. 31 is a plane view of a fixed position at the first soldier beam of the guide member of the seventh embodiment.

Best Mode for Carrying Out the Invention

With reference to the figures, the preferred embodiments of the present invention will be described in detail hereinbelow. In the following description. the materials, structures, and the interrelationships of the structural elements are merely descriptive examples and are not intended to limit the scope of the invention.

FIRST EMBODIMENT

First, construction of a wall forming a water barrier in accordance with the first embodiment of the present invention will be described in detail with reference to Fig. 1 (A) through Fig. 3 (B).

As shown in Fig. 1 (A) and Fig. 1 (B), a wall forming a water barrier is disposed between two guide holes 2 and 2 in a ditch 3, which extends from the surface of the ground to a point just above the bottom of the ditch, and is comprised of a self – hardening impervious body 4. The self – hardening body 4 is a hardening mixture of bentonite slurry and the self – hardening slurry comprising sodium silicate and cement as a primary component, in the ground. The ditch 3 is formed by a wire saw excavator 10.

As shown in Fig. 2, the wire saw excavator 10 is comprised of a main body and a guide apparatus for controlling the direction of movement of the main body.

The main body is comprised of:

the wire saw 11; and

driving apparatus 12 for driving the wire saw 11.

The wire saw 11 preferably consists of a material which is compatible with the material of the present invention, such as the diamond wire saw which is used in mining and the like and is adapted to the conditions of the ground (G). The driving apparatus 12 is the same as in the wire saw 11.

The guide apparatus of the wire saw excavator 10 is comprised of:

two upper guide pulleys 13 provided at the guide hole 2 in close proximity to the driving apparatus 12;

electric driving apparatuses 14 provided, respectively, at close proximity to the guide holes 2 and 2;

a bottom guide pulley 15 provided, respectively, in the bottom of the guide hole 2 and 2;

two endless cables 16 held tightly between the electric driving apparatus 14 and the bottom guide pulley 15;

pulley boxes 17 and 17' provided at the one point of the endless cable 16; and

H-section steel 18 for guiding two pulley boxes 17 and 17' disposed, respectively, in the guide hole 2.

The electric driving apparatus 14 and the bottom guide pulley 15 are disposed so as to be parallel to each other and perpendicular to the vertical axis of the wall. The pulley box 17, as shown in Figs. 3 (A) and 3 (B) in outline, is rectangular in plane view and in front view; and the upper, lower and front surfaces are not shown. The pulley box 17 has two moving pulleys 17 (a) and 17 (a); two supporting axis 17 (b) and 17 (b) for supporting the moving pulleys 17 (a) and 17 (a), respectively; and four rollers 17 (c). The pulleys 17 (a) and 17 (a) are rotatable and are located at the supporting axis 17 (b) and 17 (b), respectively, so that one pulley is disposed above the other in the plane view. The supporting axis 17 (b) and 17 (b) are rotatable and located on the inside of the pulley box 17, so that one supporting axis is provided at the upper portion of the pulley box 17, and the other supporting axis is provided at the lower portion the pulley box 17. The rollers 17 (c) are provided at both sides of the pulley box 17 (in the front view) so that each roller is rotatable at both ends of the supporting axis 17 (b) and 17 (b). The construction of the other pulley box 17' is the same as the construction of the pulley box 17 except for the disposed position of the pulley 17 (a') is as shown Fig. 2. The H-section steel guide 18 has guide channels 19 and 19, each of which is respectively disposed at the facing flanges of the H-section steel 18 so as to face the opening portion of the guide channel 19. Each guide channel 19 is formed by two angle steel portions and is fixed at the flange by one edge of each angle steel being welded to the flange, so as to face the other edge. The endless cables 16 and 16 are provided at the pulley boxes 17 and 17', respectively, in order to connect thereto.

The operation of the wire saw 11 is described next.

The wire saw 11 is run by the driving apparatus 12. The driving apparatus 12 moves in the direction indicated by the arrow (A) in Fig. 2; and the endless cables 16 rotate in the direction indicated by the arrow (C), by means of the electric driving apparatus 14; then the pulley boxes 17 and 17' are lowered, and the ditch 3 is formed as the wire saw 11 excavates the ground (G).

The driving apparatus 1 moves in the direction indicated by arrow (B); the endless cables 16 are rotated in the direction indicated by arrow (D); then the pulley boxes 17 and 17' move upward.

Next, the method of construction of the wall forming a water barrier is described.

First, the two guide holes 2 and 2 are provided at the position corresponding to the two sides of the wall forming a water barrier 1 in the ground (G), in order to excavate by a machine specified by the present invention, such as the earth auger, while pouring bentonite slurry via a pipe inserted into the ditch.

Next, the H-section steel guides 18 and 18 are provided in the guide holes 2 and 2 respectively;

the wire saw excavator 10 is placed in close proximity to the guide hole 2;

the ditch 3 is excavated by the wire saw excavator 10 in the ground (G);

the pulley boxes 17 and 17' are moved up. The sediment that is excavated is then transferred to the guide holes 2 and 2 by running the wire saw 11;

part of the bentonite slurry is drained by a sludge withdrawal pipe, a drain pipe and the like, and the self-hardening slurry 4. such as mortar, is poured into pipe 2 and 2, and the like, which is inserted into the ditch.

Next, the driving apparatus 12 is removed, the wire saw 11 descends to the bottom of the ditch 3 while it is running, and the wire saw 11 thereafter is moved up. Thereby, the bentonite slurry and the self-hardening slurry 4 are stirred and mixed, and the mixture is deposited throughout the entire length of the ditch 3.

Next, the H-section steel guide 18 is withdrawn from the guide holes 2 and 2.

As self-hardening slurry 4 solidifies, the wall forming a water barrier 1 is constructed.

The function and the advantages of the wall forming a water barrier 1, constructed as described above, and the construction method thereof, is described next.

Since the moving pulleys 17(a) and 17(a') of the pulley boxes 17 and 17' are arranged at different positions in plane view, the upper portion and lower portion of the wire saw 11 between the moving pulleys 17(a) and 17(a') are not disposed so that one pulley is positioned above the other

pulley in the plane view. Accordingly, it is possible to excavate a ditch 3 with a thickness that is two times greater than the diameter of the wire saw 11, in a single excavation.

In the prior art, a sheet forming a water barrier was often broken in. Because such a sheet is not used in the present invention, it is possible to prevent the leakage or seepage of water due to a broken sheet forming a water barrier.

Since the self-hardening slurry 4 extends throughout the entire length of the ditch 3 travelled by the wire saw 11, it is possible to construct a wall forming a water barrier 1.

Since the prior art wire saw can be adopted as the wire saw 11, it is not necessary for a new wire saw to be developed.

Since bentonite slurry, which has an ability to prevent water seepage, is used, it is possible to prevent seepage or leakage of the ground water into a water-absorbing stratum of the excavation area, and thereby prevent breaking of the ditch 3.

The self-hardening slurry 4 comprising sodium silicate and the cement as the primary component, and a mixture of bentonite slurry and polyethylene, or bentonite slurry and asphalt is adopted. Furthermore, the property of self-hardening slurry is adopted for the impervious materials.

The self-hardening slurry 4 is mixed with the bentonite slurry in the above embodiment. However, only self-hardening slurry is adopted as the construction material for the wall forming a water barrier 1.

The H-section steel 18 is removed in the above embodiment; however, it may also be buried in the ground without being removed.

The shape of the wall forming a water barrier 1 is the shape as in Fig. 1(A) and Fig. 2(B). However, it is possible for the wall forming a water barrier 1 to be disposed in a slanted position in the ground. As shown in Fig. 4, the wall forming a water barrier is of a curved shape in the vertical section view. In particular, it is possible that the strength of the steel comprising the wall forming a water barrier corresponds to the pressure of the earth from outside (from the left in Fig. 5) of the curve of the wall forming a water barrier 1''. This strength is larger than the above strength of the wall forming a water barrier 1. The numbers 1' indicate a wall forming a water barrier.

SECOND EMBODIMENT

Next, a wire saw excavator in accordance with the second embodiment will be described in detail and with reference to Figs. 6 and 7.

The wire saw excavator (A) is, as shown in Fig. 6, comprising:

two H-section steel guides 20 provided, respectively, in the guide holes 2 and 2 excavated in the ground (G);

two pulley boxes 21 and 21 which can be moved up and down, disposed on the H-section steel guides 20 and 20, respectively;

auxiliary apparatuses 22 for moving two pulley boxes 21 and 21 in the upward and downward direction;

pulleys 33 provided at the upper portion of the H-section steel guides 20 and 20, respectively;

a wire saw 26 for excavating a ditch 3 between the guide holes 2 and 2, and is held tightly at the pulleys 33;

an electric motor 32 for driving the wire saw 26; and

graspers 35 and 35 for pulling the sheet, forming a water barrier 39, into the ditch 3 as the pulley boxes 21 and 21 descend into the ditch 3, and for grasping a sheet that is a construction element of the wall forming a water barrier 39.

The H-section steel guides 20 are provided in guide holes 2 and 2, respectively, which are located at the positions corresponding to the ends of the ditch 3 in the ground (G), and which extend from the surface of the ground (G) to the portion of the ground (G) which is deeper than the bottom of the wall forming a water barrier 1. The guide holes 2 and 2 are formed by excavating with an earth auger and the like.

Each pulley box 21 is a box which opens at the upper and lower surfaces thereof and form a curved shape similar to the letter "C", and has a moving pulley 21(a) therein. Each moving pulley 21(a) is rotatable. As shown in Fig. 7, a stopper 21(b) is provided on the inside of the pulley box 21. Each stopper 21(b) is in the shape of an inverted letter "L".

The auxiliary apparatus 22 is comprised of the following:

four tackles 23 disposed, respectively, at each H-section steel 20;

cable 24 held tightly between each of the four tackles 23 of each H-section steel 20; and

a carriage motor 25 for driving the cables.

Two of the four tackles 23 are rotatable at the base 32 and are located at the upper portions of each H-section steel 20. Another pair of tackles 23 are rotatable at the lower portions of each H-section steel 2. Each tackle is rotatable in the vertical plane. Each cable 24 is connected, respectively, at the pulley box 21 so that the end thereof is fixed at the upper portion of each pulley box 21, and the other end thereof is fixed at the lower portion of each pulley box 21. Each carriage motor 25 is fixed on each base 32, and is an electrically-driven motor. One tackle 23 of the pair of tackles 23 and 23 disposed at the base 32 is

located at the output axis of the carriage motor 25. The carriage motor 25 can also be disposed at another position so that the cable 24 is consequently extended.

One pulley 33 is disposed at the upper portion of the H-section steel 20 which is located on the left side (H-section steel 20 on left side in Fig. 6). Two pulleys 33 are disposed at the upper portion of the H-section steel 20 located on the right side (H-section steel 20 on the right side in Fig. 6) . Each pulley 33 is rotatable in the vertical plane. However, each pulley 33 is disposed so that the wire saw 26 does not make contact with the cables 24. Consequently, each pulley 33 does not overlap with the moving pulley 21(a).

The wire saw 26 is similar to the wire saw in accordance with the first embodiment. However, in the second embodiment, the wire saw 26 is held tightly and extends from the electric motor 32 to the pulleys 33 disposed on the H-section steel 20 located on the right side (H-section steel 20 on the right side in Fig. 6), therefrom to the moving pulley 21(a) on the pulley box 21 located on the right side [moving pulley 21(a) on the right side in Fig. 6], therefrom to the moving pulley 21(a) in pulley box 21 on the left side thereof [moving pulley 21(a) on the left side in Fig. 6], therefrom to the pulley 33 provided on the H-section steel 20 located on the left side (H-section steel 20 on the left side in Fig. 6), and therefrom to the electric motor 32. Furthermore, an expansion apparatus 27 is provided between the pulleys 33 provided on the H-section steel 20 located on the right side (expansion apparatus 27 on the right side in Fig.6). The expansion apparatus 33 is comprised of a support frame 28, a plurality of hanging pulleys 30 which are rotatable on the support frame 28, and a carriage 31 which is horizontally movable (right and left side in Fig. 6) on the surface of the ground (G). The support frame 28 has two support bodies 29 and 29. One support body 29 is disposed on the surface of the ground (G), in close proximity to the H-section steel 20 located on the right side (support body 29 on the right side in Fig. 6). The other support body 29 is attached to the left end portion of the carriage 31 (support body 29 on the left side of carriage 31 in Fig.6). Therein, the wire saw 26 from the H-section steel 20 located on the left side (wire saw 26 from H-section steel 20 on the left side in Fig. 6) is held tightly from below and above by the hanging pulley 30. The electric motor 32 is fixed on the right end portion of carriage 31. Each grasper 35 is, as shown in Fig. 7, comprised of a clamp 36 for grasping the sheet forming a water barrier 39, a ring 37 in which cable 24 is passed through, and a cable 38 which is connected at one end to the clamp 36 and at the other end to the ring 37. The clamp 36 can grasp the lower corner of the sheet forming a water barrier 39 by fastening a bolt 36(a). The ring 37 has a diameter which is far smaller than the width of the pulley box 21. The cable 38 is preferably a wire and the like.

The length of the sheet forming a water barrier 39 is a little longer than the ditch 3, and both sides of the sheet are disposed in the guide holes 2 and 2. Furthermore, in the second embodiment, as shown in Fig. 7, both ends of the sheet forming a water barrier 39 are attached, respectively, to two Spanseal (trademark) boards forming a water barrier 40 and 40. The Spanseal board forming a water barrier 40 is made of a material which is an elastomer combined with a water-absorbing polymer. The water-absorbing polymer is obtained by adding a low ratio of bridge structures to a water-soluble molecule such as polyacrylic acid. Accordingly, the Spanseal board forming a water barrier 40, which is made of material which is swollen by water, is swollen by water in the ground G or by water from the concrete.

The wire saw excavator (A) has a soil discharge apparatus 41 for discharging soil from the guide hole 2. The soil discharge apparatus 41 is comprised of a soil discharge pipe 42 and a pump 43. The soil discharge pipe 42 has one end thereof in the guide hole 2, and the other end connected to the pump 43. The pump 43 is preferably an apparatus, such as a suction pump or an air compression type vacuum pump and the like.

Furthermore, a protection frame 44 is inserted at the opening of the guide hole 2 as shown in Fig. 6. The protection frame 44 is a short pipe body which is made from steel, has a flange at the end thereof and has an opening for pulling the wire saw 26 and the sheet forming a water barrier 39 in the guide holes 2 and 2.

Next, the operation of the above-described wire saw excavator (A) is described.

The H-section steel 20 guides the movement of the pulley box 21 upwards and downwards.

The pulley box 21 guides the movement of the wire saw 26 upwards and downwards, and prevents the wire saw 26 from deviating off course in a sideways direction.

Because the lower portion of the pulley box 21 is open, the stopper 21 (b) supports the cable 38 when the pulley box 21 descends, and therefore prevents the cutting of the cable 38 by the wire saw 26.

The auxiliary apparatus 22 drives the pulley box 21 upwards and downwards, independent of the operation of the wire saw 26.

The support body 29 on the right side (in Fig. 6) can move towards or away from the support body 29 on the left side (in Fig. 6) by moving the carriage 31, and thereby making it possible for the

extension apparatus 27 to control the length of the wire saw 26 from the expansion apparatus 27. That is, the length of the wire saw 26 is longer when the right support body 29 moves in the direction of the arrow (E) shown in Fig. 6. The length of the wire saw 26 is shorter when the right support body 29 moves in the direction of the arrow (F) shown in Fig. 6. Therefore, it is possible to adjust the length of the wire saw 26, so that it is proportional to the depth of the ditch, during excavation, via the upward and downward movement of the pulley boxes 21.

The wire saw 26 runs in the direction of the arrow (W) (Fig. 6) and, by the driving force of the electric motor 32, excavates the ground (G), and forms the ditch 3.

The clamp 36 grasps the lower portion of the sheet forming a water barrier 39. The cable 24 passes through the ring 37 in order to support the ring 37. Accordingly, the grasper 35 goes down when the pulley box 21 goes down, thereby pulling the sheet forming a water barrier 39 into the ditch 3.

The soil discharge apparatus 41 discharges the excavated soil and the supplied bentonite slurry from the bottom of the guide hole 2 to the surface of the ground (G) via the opening of guide hole 2 . The reason the soil discharge apparatus 41 is provided only on the guide hole 2 on the left side (in Fig. 6), is because the excavated soil is transferred to the left side guide hole 2 as the wire saw 26 runs from right to left (in Fig.6), in the bottom of the ditch 3.

The protection frame 44 prevents collapse of the side walls at the opening of the guide holes 2 and 2.

The two Spanseal boards forming a water barrier 40 are swollen by water in the mud slurry.

Next, the method of construction of the wall forming a water barrier using the wire saw excavator (A) is further expanded with reference to Fig. 8(A) and 8(D).

First, the guide holes 2 and 2 are formed by excavating at positions corresponding to both sides of the ditch 3, and are constructed by the same method described in the first embodiment.

Next, the wire saw excavator (A) is disposed in the ground (G) because the H-section steel guides 20 and 20 are, respectively, disposed in the guide holes 2 and 2. Then, the pulley boxes 21 are disposed at the upper portion of the H-section steel guides 20 and 20. The sheet forming a water barrier 39 is rolled, as shown in Fig. 8(A), and is rotatable between two H-section steel guides 20 so as to be above the ditch 3 to be excavated. The lower portion of the sheet forming a water barrier 39 is grasped by the clamps 36 and 36 of the graspers 35 and 35. The cable 38 is supported at the stopper 21 (b) (not shown in Fig. 8(A)).

Next, as shown in Fig. 8(B), the ground (G) is excavated and the sheet forming a water barrier 39 is pulled into the excavated ditch as the wire saw 26 and carriage motor 25 are driven, and thereby forming the ditch 3. Then, the mud and slurry are poured into the guide holes 2 and 2 to prevent jamming of the wire saw. The soil discharge apparatus 41 is moveable so that the mud and slurry will not fill up with the mud slurry and in order to discharge excavated soil.

Next, the wire saw 26 is cut and is pulled up after the excavation of the ground (G), and the sheet forming a water barrier 39 is pulled into the ditch.

Next, as shown in Fig. 8(C), the pulley boxes 21 and 21 are disposed at the upper portion of the H-section steel 20 by auxiliary apparatuses 22 and 22. The sheet forming a water barrier 39 remains in the ditch 3 even after the ditch 3 is formed because the sheet 39 is not connected to the pulley boxes 21 and 21. Because the lower portion of the stopper 21(b) (not shown in Fig. 8-(C)) is open, the cable 38 does not go to the same depth as the pulley boxes 21 and 21.

Next, as shown in Fig. 8(D), the pulley boxes 21 and 21 and the H-section steel guides 20 and 20 are retrieved by means of the cables 38 and 38.

Thereafter, the adjacent ditch is executed.

The wall forming a water barrier 1 is constructed by repeating the above process. The concrete is poured into the guide holes 2 and 2 after the sheets forming a water barrier 39 and 39, which are adjacent to each other, are disposed in parallel in the ditches 3 and 3.

Next, the advantages of the wire saw excavator (A) are described.

The wire saw excavator (A) constructed as described above has the same advantages as in the first embodiment.

Furthermore, since the wire saw excavator (A) has the graspers 35 and 35, the sheet forming a water barrier 39 is pulled into the ground (G) while excavating.

Because the two Spanseal boards forming a water barrier 40 and 40 are attached to both sides of each sheet forming a water barrier 39, and because a Spanseal board will swell in each guide hole 2 and 2, the ability to prevent water seepage is maintained.

Due to the wire saw extension apparatus 27, the movement of the electric motor 32 is less than that of the wire saw excavator in accordance with the first embodiment.

Since the grasper 35 is a separate body from the pulley box 21, and moreover, does not grasp the sheet forming a water barrier 39, it is possible to pull up the pulley box 21 and the wire saw 26

from the guide hole 2 and the ditch 3 during excavation, leaving only the sheet forming a water barrier 39 inside the ditch 3.

Since the auxiliary apparatus 22 makes the wire saw 26 go up and down independent of the electric motor 32, it is possible to excavate equally between the guide holes 2 and 2, and to easily pull the sheet forming a water barrier 39 in the ditch 3, while controlling the height of the pulley box 21.

Since the pulley box 21 prevents sideways deviation of the wire saw 26, it is possible to excavate a vertical ditch 3 in ground (G) of uneven hardness.

The grasper 35 is constructed as above; however, this is not intended to limit the scope of the invention; other apparatuses capable of grasping and being disposed in the ditch 3, such as the apparatus shown in Fig. 9 may also be adopted. The apparatus shown in Fig. 9 comprises a clamp 51 for the lower portion of the sheet forming a water barrier (not numbered in Fig. 9); a ring 52 with a cable which is passed through the ring 52 and connected to a pulley box; a ball 53 which is fixed at the cable 24 for stopping the ring 52; a string 54 having one end thereof connected to the clamp 51, and having the other end thereof connected to the rings 52; and protection ring 55 which the wire saw passes through (not numbered in Fig. 9).

In the second embodiment, the sheet forming a water barrier 39 is pulled into the ditch 3 while the wire saw 26 is excavating the ditch. However, it is also possible for the sheet forming a water barrier 39 to be pulled into the ditch 3 after the ditch 3 is formed, by operating the wire saw 26.

THIRD EMBODIMENT

Next, a wire saw excavator in accordance with the third embodiment will be described in detail.

Fig. 11 is a side view of a wire saw excavator in accordance with the third embodiment. In Fig. 11, numeral 111 indicates a guide hole which is excavated in the ground (G). At least two guide holes 111 and 111 are disposed in an excavation area (S) of a ditch at the appropriate distance. The guide holes 111 and 111 are formed so as to have sufficient depth for excavating the ditch.

In the two adjacent guide holes 111 and 111, guide columns 112 and 112 are inserted, respectively. Each guide column 112 is made of channel steel and is provided so as to direct the opening portion of one channel steel to the opening portion of the other channel steel. Inside the guide column 112, rails 113 are provided for sliding carriages (a driving carriage 115 and a control carriage 130) as described hereinafter, so as to extend in the upward and downward direction of the guide column 112. The clearance 113 (a) is formed between the rails 113 and 113, which have plural pin racks 114 and 114 at regular intervals. The pin rack 114 comprises a pin rack system of a travel mechanism 116.

A moveable driving carriage 113 is disposed on the rail 113, which is disposed on the guide column 112 in the other guide hole 111, to move in the upward and downward direction.

The driving carriage 113 is comprised primarily of the above-described travel mechanism 116 for moving the driving carriage up and down, an excavating portion 117 and a casing 118 of the travel mechanism 116, and the excavating portion 117 as shown in Figs. 12 and 13.

The casing 118 is comprised of a sliding back plate 118 (a) disposed so that it can move up and down while grasping the rail 113 of the guide column 112; and the cover plate 118(b) which is attached to the back plate 118(a), disposed so that it can open and close, and protrudes towards the front so as to ensure an internal space between the cover plate 118(b) and the back plate 118(a) . The internal space of the casing 118 is divided into the upper space 119(a) and the lower space 119(b) by a diaphragm 118(c). The travel mechanism is retracted into the upper space 119(a), and the excavated portion 117, which has the function of excavating the ground (G), is retracted into the lower space 119(b). A slit 118(d) is formed for passing the wire saw 127 through to the casing 118 corresponding to the lower space 119(b). A pin rack system is adopted in the travel mechanism 116 in the upper space 119(a), as shown in Fig. 15, which can move up and down by means of meshing between a pin rack 114 and 114 and a pinion 120. More specifically, the pinion 120 is formed so as to have five teeth 120(a) disposed in a star-shaped arrangement, and the pinion 120 is disposed so as to mesh with the travel mechanism 116. In addition, a slit 118 (e) is provided at the position of the back plate 118(a), which corresponds to the pinion 120, so as to mesh with the pin rack 114. An oil compression cable 126 is connected to a drive mechanism (not shown in Fig. 13) for rotating the pinion 120.

The excavating portion 117, provided at the lower space 119(b) of the casing 118 comprises three pulleys (the first pulley 121, the second pulley 122, and the third pulley 123); the wire saw 127 is held tightly from the first pulley 121, the second pulley 122, and the third pulley 123; and an oil compression motor 128 is connected to the first pulley 121 for driving the first pulley 121. The first pulley 121, the second pulley 122, and the third pulley 123 are rotatable in the same vertical plane. The second pulley 122 is disposed so that it is obliquely rotatable above the first pulley 121, so as

to create friction therebetween and the wire saw 127. The third pulley 123 is disposed so that it is directly rotatable above the first pulley 121. The wire saw 127 is pulled out from the slit 118(d) to the outside of the casing 118, which is held tightly from the fourth pulley 124 and the fifth pulley 125 which are provided at the excavating portion 117 of the control carriage 130. That is, the wire saw 127 is held tightly from the first pulley 121, the second pulley 122, the third pulley 123, the fourth pulley 124 and the fifth pulley 125. The wire saw 127 thereby, as a whole, forms an endless wire. Furthermore, a wire saw length controller 129 is provided on the inside of the casing 118, and the third pulley 123 is provided at thereat.

The wire saw length controller 129 makes it possible to provide any length wire saw 127 from the pulleys 121, 122, 123, 124, and 125 by moving the mechanism up and down according to the required length of the wire saw 127.

As shown in Fig. 11, the control carriage 130 is disposed so that it is moveable along the rail 113 which is provided at the guide column 112 in the other guide hole 112. The control carriage 130 comprises a travel mechanism 116' for moving the driving carriage up and down on an excavating portion 117', a casing (not indicated in Fig. 11) of the travel mechanism 116', and the excavating portion 117, as in the driving carriage 115 described above. The description of the travel mechanism 116' and the excavating portion 117 are omitted because the construction of the travel mechanism 116' is identical to the construction of the driving carriage 115 already described.

The excavating portion 117' is provided at the casing, as shown in Fig. 16, which is comprised of the fourth pulley 124 and the fifth pulley 125 which are rotatable in the vertical plane, and the wire saw 127.

The fourth pulley 124 is provided at the upper portion of the control carriage 130, and the fifth pulley 125 is provided at the lower portion of the control carriage 130. As shown in Figs. 16 and 17, the fourth pulley 124 is disposed so that it can be moved up and down, and the upper portion thereof is rotatable and connected to a spring tensioner 131 which is provided between the casing (similar to casing 118) and the diaphragm (similar to diaphragm 118(c)) . The spring tensioner 131 is provided in order to maintain the constant tension of the wire saw 127, and so that it is possible for the fourth pulley 124 to move up and down by extension thereof. Specifically, as shown in Fig. 16, the spring tensioner 131 is shortened when the driving carriage 115 and the control carriage 130 are in the same horizontal plane. As shown in Fig. 17, the spring tensioner 131 is extended when the position of the driving carriage 115 is lower than the position of the control carriage 130.

Next, the construction process of the wall forming a water barrier in the ground (G) using the wire saw excavator 110, is described.

First, as shown in Fig. 18, the plural guide holes 111 and 111 are formed by excavating along the circumference of the area where the wall forming a water barrier in the ground (G) is to be constructed, in order to attain a predetermined distance therebetween and an appropriate depth.

Next, a guide column is provided in each guide hole 111.

Next, as shown in Fig. 19, the wire saw excavator 110 is pulled into the ground (G). Specifically, the driving carriage 115 in one of the adjacent two guide holes 111 and 111 and the control carriage 130 in the other guide hole 111 are moved down along each guide column 112. The movement of the driving carriage 115 and the control carriage 130, for moving down, are operated by travel mechanisms 116 and 116, respectively. The pinion 120 of the travel mechanism 116 is rotated by the motor (not shown in Figs. 16 and 17); then the pinion teeth 120(a) of the pinion 120 meshes with the pin rack 114; and thereby, the driving carriage 115 and the control carriage 130 are driven up and down. At the same time, the wire saw 127 is driven as the first pulley 121 is rotated by means of the oil compression motor 128. The ditch is formed by excavating between the guide holes 111 and 111 in accordance with the excavation of the ground (S), because the wire saw 127 is running while it is moved by the downward movement of the driving carriage 115 and the control carriage 130. The driving carriage 115 and the control carriage 130 are moved up by the travel mechanisms 116 and 116 after the ditch is formed between the guide holes 111 and 111 in the ground (G), and when the driving carriage 115 and the control carriage 130 arrive at the bottom of the guide holes 111 and 111. At the same time, the excavated soil is transferred thereby. The driving carriage 115 and the control carriage 130 are not in the same horizontal plane because the driving carriage 115 and the control carriage 130 are made to go up and down independent of each other. If the driving carriage 115 and the control carriage 130 are not in the same horizontal plane, the tensioner 131 is extended and the vertical position is controlled by the driving carriage 115 and the control carriage 130. Therefore, it is possible for the driving carriage 115 and the control carriage 130 to be moved up and down.

Next, the sheet 132 is pulled into the ditch, which is formed as described above, and thereby a sheet forming a water barrier 132 is constructed. The method of pulling the sheet forming a water barrier 132 in the ditch, as shown in Fig. 20, is as

follows. Both sides in the lower portion of the sheet forming a water barrier 132 are connected to each upper portion of the driving carriage 115 and the control carriage 130 by cable 133 and the like, respectively, and in this condition, the driving carriage 115 and the control carriage 130 are moved downward into the ditch. With respect to the connections between the driving carriage 115 and one side of the lower portion of the sheet forming a water barrier 132, and between the control carriage 130 and the other side of the lower portion of the sheet forming a water barrier 132, a construction may be adopted which is detachable therebetween in the ditch. For instance, the components of this construction comprises: a vertical hole provided at the upper surface of the driving carriage 115 and the control carriage 130, respectively; a rope connected, respectively at both sides of the lower portion of the sheet forming a water barrier 132, with each end of the rope being ring-shaped; two pins which can be inserted and fixed in the hole and can be pulled, with the head of each pin being larger than the diameter of the ring formed by the rope so that it can suspend the ring. In this method of construction, the pin is first inserted into the hole, through the ring formed by the rope, before excavation. The pin is then pulled out after the sheet forming a water barrier 132 arrives nearly to the bottom of the ditch. Each pin is pulled from the hole and ring by a manually-operated pulley rope. The sheet forming a water barrier 132 is thereby detached from the driving carriage 115 and the control carriage 130. Thereafter, only the driving carriage 115 and the control carriage 130 are moved up in the guide holes 111 and 111, and are retrieved thereby.

Next, the operation and the advantages of the wire saw excavator 110, constructed as in the above, are described.

Because the wire saw excavator comprises, in general, the driving carriage 115 and the control carriage 130 which are moveable in the upward and downward direction along the guide columns 112 and 112 disposed in two adjacent guide holes 111 and 111; and the wire saw 127 which is held tightly between the driving carriage 115 and the control carriage 130; it is possible for the ground (G) to be excavated by the wire saw 127, and the ditch to be formed, as the driving carriage 115 and the control carriage 130 are moved downward along the guide columns 112 and 112.

Furthermore, since the excavating portions 117 and 117' are provided at the driving carriage 115 and the control carriage, 130 respectively, and since the wire saw 127 is held tightly therebetween, the excavating portions 117 and 117' move up and down as the driving carriage 115 and the control carriage 130 move up and down along with the upward or downward movement of the wire saw 127. Accordingly, this part of the wire saw 127 is shorter than the wire saw 127 exhibited in the prior art. Therefore, it is not necessary to further extend the wire saw 127, and, consequently, the ditch is formed by the wire saw 127 of a relatively short and constant length. Therefore, it is possible for the wire saw excavator 110 to be smaller than in the prior art, and the performance of the wire saw excavator 110 to be improved. Therefore, the use of a wire saw excavator 110 is preferable in the case of excavating a ditch of great depth and construction of a wall forming a water barrier for such a ditch.

Since the travel mechanisms 116 and 116 are provided at the driving carriage 115 and the control carriage 130, it is possible to make the driving carriage 115 and the control carriage 130 move up and down. Furthermore, the tensioner 131, as a tension control apparatus, is provided at the travel portion 116 of the control carriage 130 and therefore the tension of the wire saw 127 is kept constant in spite of the horizontal position of the driving carriage 115 and the control carriage 130. It is therefore possible for the wire saw 127 to excavate the ground (G) under the best conditions.

The wire saw excavator 110 is not limited to the third embodiment. Accordingly, it is possible to modify specific parts thereof, such as the driving carriage 115, the control carriage 130, the travel mechanism 116, the excavating portion 117, and the wire saw 127.

For example, the other mechanism of the tensioner 131 indicated in the third embodiment, the mechanism shown in Figs. 21 and 22, can be adopted as the mechanism for controlling the tension of the wire saw 127. In this mechanism, a running pulley 134' is disposed so that it is able to move up and down at the center of the line between the fourth pulley 124' and the fifth pulley 125'; a fixed but rotatable pulley 135' is disposed above the running pulley 134' and at the side of driving carriage 115. In this case, a wire saw 127' is held tightly from the first pulley 121, the second pulley 122, the third pulley 123, the fourth pulley 124', the running pulley 134', the fixed pulley 135', the fifth pulley 125', and the first pulley 121.

In the wire saw control mechanism constructed as described above and as shown in Fig. 21, if the driving carriage 115 and the control carriage 130 is positioned horizontally, then the running pulley 134' and the fixed pulley 135' will be distanced from each other. However, if the driving carriage 115 is below the control carriage 130 as shown in Fig. 22, the running pulley 134' is then adjacent to the fixed pulley 135' because the running pulley 134' is pulled by the tension on the wire saw 127.

The construction of the travel mechanism 116 and 116' provided on the driving carriage 115 and the control carriage 130 is not limited to a pin rack system as in the above third embodiment and other systems (for example, hoist gear mechanism) may be adopted.

The numbers and positions of the pulleys 121 through 125 provided at the excavating portion 117 and 117' are not limited to the above third embodiment, the construction is able to tightly hold and maintain the constant tension of the wire saw 126, which is adopted.

FOURTH EMBODIMENT

Next, a landslide protection wall and method of construction thereof in accordance with the fourth embodiment will be described in detail with reference to Figs. 23 through 28.

In Figs. 23 through 26, numeral 201 is a sheet forming a water barrier wall in accordance with the landslide protection wall.

The wall forming a water barrier 201 is comprised of guide holes 203 in the ground (G) which are disposed at a specified distance; a first soldier beam 202(a) and a second soldier beam 202(b) alternately disposed in the guide holes 203; a ditch 204 provided between the guide holes 203; a sheet forming a water barrier 205 disposed in the ditch 204; and a horizontal sheathing 206 provided at the first soldier beam 202(a) and the second soldier beam 202(b).

As shown in Fig. 23, the first soldier beam 202(a) is made of H-section steel. The lower portion of the second soldier beam 202(b) is H-section steel, tapering at the lower portion thereof. The first soldier beam 202(a) is provided at the guide hole 203 so that a flange 202(c) thereof faces the excavated surface (Ga) of the ground(G).

The second soldier beam 202(b) is provided at the guide hole 203 so that a flange 202(c) of the tapered side faces the excavated surface (Ga) of the ground (G), the tapered side is provided so that it slants in proportion to the movement from one flange to the other flange on one edge.

As shown in Fig. 23, the two guide materials 202(d) are fixed at both sides of one flange 202(c) of the first soldier beam 202(a). As shown in Fig. 25, each guide material 202(d) is C-shaped in transverse sectional view, and the open portion thereof faces outward because the portion corresponding to the middle portion of the C is fixed.

The guide material 202(d) is the same length as the soldier beam 202(a). The portion of each guide material 202(d) corresponding to the open part of the C forms a guide channel 202(e) which passes through the longitudinal plane of the guide material 202(d).

As shown in Fig. 24, the guide hole 203 is formed by excavating vertically for a specified distance in the horizontal plane, and has the shape of a circle in the transverse sectional view shown in Fig. 23. The guide hole is is then excavated along the longitudinal direction so that the capacity thereof is reduced by half when the construction is completed.

The ditch 204 is formed so that the width thereof is larger than the width of the sheet forming a water barrier 205, which is provided at the excavating surface (Ga) of the ground (G).

The guide hole 203 and the ditch 204 are then filled with the bentonite mortar 208.

As shown in Fig. 23, the sheet forming a water barrier 205 is made from synthetic resin and the like, which has the flexibility and ability to prevent water seepage. Connecting portions 207, which are connected to the guide channel 202(e), are provided at both sides thereof so that the sheet forming a water barrier 205 is tautly disposed in the ditch 204. Each connecting portion 207 is formed so that both sides thereof are of greater thickness than any other part thereof, and in which a steel coil 207(a) is provided. The sheet forming a water barrier 205 is held tightly between the guide holes 203 and 203 because both sides thereof are fixed by the hardened bentonite mortar in the guide holes 203 and 203.

The method of construction of the landslide protection wall is constructed as described above.

As shown in Fig. 25, the guide holes 203 and 203 are first formed by a boring machine and the like.

Next, as shown in Fig. 26, a wire saw apparatus 209 and a sheet providing apparatus 210 are set in this space, and the guide pile 211 is disposed in the guide holes 211 and 211.

Next, the wire saw apparatus 209 and the sheet providing apparatus 210 are disposed in close proximity to the guide holes 211 and 211.

Next, guide piles 211 and 211 are provided in each guide hole 203.

Next, the ditch 204 is formed between the guide holes 211 and 211, and the sheet forming a water barrier 205 is pulled therein by the sheet providing apparatus 210.

As shown in Fig. 26, the guide hole 211 has thin steel members 211(a) and 211(a) which are respectively fixed on the side, running along the longitudinal axis of the flange, and are disposed face to face. A guide portion 211(b) is disposed between the thin steel members members 211(a) and 211(a), wherein the guide portion 211(b) is provided.

As shown in Fig. 26, the wire saw apparatus 209 comprises: guide holes 203 and 203 disposed in the ground; guide piles 211 and 211 disposed in

the guide holes 203 and 203; travel carriages 209(a) and 209(a) attached to the guide piles 211 and 211 which are disposed in the adjacent two guide piles 211 and 211, respectively; a drive mortar 209(b) disposed on the ground; the first winches 209(c) and 209(c) disposed at the upper portion of the guide piles 211 and 211, and thereby the wire saw 209(d) is an endless saw.

The travel carriage 209(a) is shaped like a bucket with openings 209(g) at the surfaces facing each other and disposed at the guide portions 211(b) and 211(b). The second winch 209(e) is rotatable and provided in each travel portion 209-(a). A wire saw hole 209 (f) is disposed at the upper portion of each travel carriage 209(a) so that it can pass in the vertical direction of the travel carriage 209(a).

As shown in Fig. 26, the travel carriage 209(a) can go up and down because it is connected to the travel belt 209(h) which passes through the guide portion 211(b). The travel belt 209(h) is rolled by the travel winch 209(g) which is held tightly between the upper and lower portions of the guide pile 211.

Furthermore, the upper portion and the lower portion of the sheet forming a water barrier 205 are connected to each other by a pulling wire 209(i) so that the sheet forming a water barrier 205, is thereby pulled into the ditch 204 as the travel carriage 209(a) moves downward.

The drive motor 209(b) supports the wire saw 209(d) at the end of an output axis 209(j) and therefore the wire saw 209(d) moves because the output axis rotates.

The first winch 209(c) is disposed so that an axis thereof is approximately horizontal.

The wire saw 209(d) is held tightly, in turn, by the first drive motor 209(b), one first winch 209(c) (the right side winch in Fig. 26), one second winch 209(e) (the right side winch in Fig. 26), another second winch 209(e) (the left side winch in Fig. 26), and another first winch 209(c) (the right side winch in Fig. 26). The wire saw 209(d) is held tightly between the second winches 209(c) and 209(c) in a horizontal position, and the ground (G) therebetween is excavated.

The sheet providing apparatus 210 rolls the sheet forming a water barrier 205 around a rolling rod 210(a) and supports the sheet forming a water barrier 205. The sheet forming a water barrier 205 is then pulled into the ditch 204 as the rolling rod 210(a) rotates in reverse.

The ditch 204 is formed because the ground (G) is excavated between the guide holes 203 and 203 by the wire saw 209(d) which is driven simultaneously. The sheet forming a water barrier 205 is pulled because the travel carriages 209(a) and 209(a) are moved downward to a specified depth by the travel winch 209(g) and 209(g). The ditch 204 is thereby formed, and simultaneously, the sheet forming a water barrier 205 is pulled therein.

The ditch 204 is formed and the sheet is pulled therein between the guide holes 203 and 203 as described above. One guide portion 211(b) and the other guide portion 211(b) of one guide pile 211 can, respectively, guide one side of one sheet forming a water barrier 205 and one side of the adjacent sheet forming a water barrier 205. As shown in Fig. 27, the sheet forming a water barrier 205 is pulled into the ditch 204 so that both sides (i.e. the vertical parts) thereof are in the guide holes 203 and 203.

The sheet forming a water barrier 205 pulled into the ditch 205 is cut from the sheet providing apparatus 210, as shown in Fig. 27, two suspension wires 207(b) and 207(b) are disposed, respectively, at both sides of the upper portion of the sheet forming a water barrier 205, and the sheet forming a water barrier 205 is supported by two suspension bars each of which is passed, respectively, through the suspension wires 207(b) and 207(b).

After the ditch 204 is formed and the sheet forming a water barrier 205 is pulled therein, the guide pile 211 is pulled out of the guide hole 203. Next, the bentonite mortar 208 is placed between the excavating surface (Ga) and the outer surface of the flange of the guide pile 211 in the guide hole 203, and between the excavating surface (Ga) and the sheet 205. Then, the first soldier beams 202(a) are disposed in every other guide hole 203 before the bentonite mortar 208 hardens. Next, the sheet forming a water barrier 205 is pulled into the ditch 4 so that each connecting portion 207 is inserted into the guide channel 202(e) from the upper portion thereof. Thereby, each connecting portion 207 is connected to each guide material 202(d).

After the first soldier beams 202(a) are provided in every other guide hole 203, as shown in Fig. 28, the bentonite mortar 208 is poured into the guide holes 203 which are between the first soldier beams 202(a) and 202(a). Next, the second soldier beams 202(b) are provided in the guide holes 203 where the first soldier beams 202(a) are not disposed. The second soldier beams 202(b) are disposed between the sheet forming a water barrier 205 and the excavating surface (Ga) so that the slant thereof faces the excavating surface, and so that the flange thereof contacts the sheet forming a water barrier 205.

After the first soldier beams 202(a) and the second soldier beams 202(b) are disposed in the guide holes 203, the ground (Gb) between the guide holes 203 and 203 is excavated. As shown in Fig. 23, the horizontal sheathings 206 are provided between the web of the first soldier beams 202-

(a) and the web of the second soldier beams 202-(b), so as to form a wall-like structure.

After the horizontal sheathings 206 are provided, the bentonite mortar 208 is placed between the sheet forming a water barrier 205 and the horizontal sheathing 206, so that the wall forming a water barrier 201, which has the ability to prevent water seepage, is constructed. Thereby, a landslide protection wall which has a higher ability to prevent water seepage, is constructed.

According to the landslide protection wall constructed as described above, and because the bentonite mortar 208 is placed between the excavating surface (Ga) and the outer surface of the flange of the guide pile 211 and the guide hole 203, and between the excavating surface (Ga) and the sheet 205, it is therefore possible to improve the ability of the landslide protection wall to prevent water seepage, in comparison with the landslide protection wall constructed in accordance with the prior art. Since it is easy to adopt the sheet forming a water barrier 205 as the landslide protection wall using the horizontal sheathing 206, it is possible to execute the placement thereof in close proximity to a building that is adjacent to the excavation site. Therefore, the flexibility of the landslide protection wall is improved.

According to the method of construction described above, and because the ditch 204 is formed by excavating the ground (G),at the same time the sheet forming a water barrier 205 is pulled in, the efficiency of excavation is improved. Since the sheet forming a water barrier 205 is pulled into the ditch 204 easily and accurately, the precision of the execution is also improved.

Since the bentonite mortar 208 is poured when the connecting portion 207 and the guide material 202(d) are connected to each other, it is possible to improve the water impermeability of the connection between the connecting portion 207 and the guide material 202(d).

FIFTH EMBODIMENT

A landslide protection wall and construction method thereof in accordance with the fifth embodiment will be described in detail with reference to Fig. 29.

The construction of the landslide protection wall is similar to the construction of the landslide protection wall constructed in accordance with the fourth embodiment, except that the position of the guide material 202(e) differs. Construction materials which are identical to those used in the fourth embodiment are numbered with the same numerals used in the description of the fourth embodiment.

In the fifth embodiment, as shown in Fig. 29, two guide materials 202(d) and 202(d) are fixed at the web 202(f) of each first soldier beam 202(a). Specifically, each guide material 202(d) is welded at approximately the center of the web 202(f), as shown in the transverse sectional view, so that the open portion thereof faces outward. To construct the landslide protection wall, the sheet forming a water barrier 205 is provided in the ditch 204 on condition that the connecting portion 207 thereof is provided at the center of both surfaces of the web 202(f), as shown in the transverse sectional view, and the second soldier beam 202(b) is provided in the guide hole 203 between the first soldier beams 202(a) and 202(a), so that the part of the sheet forming a water barrier 205 is bowed with respect to the excavated surface (Ga). The sheet forming a water barrier 205 is thereby held tightly in the ditch 204.

According to the landslide protection wall constructed as described above, because the sheet forming a water barrier 205 is held tightly in the ditch 204 and the slackening thereof is slight, and because the bentonite completely fills in the guide holes 203 and the ditch 204, there is no void area in the ditch 204. Therefore, the quality of the wall forming a water barrier 201 is improved.

Furthermore, since the sheet forming a water barrier 205 is held tightly in the ditch 204 without slackening, the bentonite is poured smoothly into the ditch 204. Therefore, the efficiency of construction is improved.

SIXTH EMBODIMENT

A landslide protection wall and construction method thereof in accordance with the sixth embodiment will be described in detail with reference to Fig. 30.

The construction of the landslide protection wall is similar to the construction of the landslide protection wall constructed in the fourth embodiment except that the positioning of the guide material 202(e) differs. Construction materials which are identical to those used in accordance to the fourth embodiment are numbered with the same numerals used in the description of the fourth embodiment.

In the sixth embodiment, as shown in Fig. 30, two guide materials 202(d) and 202(d) are fixed at the corner between the flange 202(c) on the side of the excavating surface (Ga) and the web 202(f) of each first soldier beam 202(a).

According to the landslide protection wall constructed as described above, because each guide material 202(d) is disposed at the flange 202(c) on the side of the excavating surface (Ga), the distance between the sheet forming a water barrier 205 and the excavating surface (Ga) is shorter as compared with the distance according to

the fifth embodiment. Accordingly, the quantity of the bentonite mortar between the excavating surface (Ga) and the sheet forming a water barrier 205 is smaller. Therefore, the stress in the sheet forming a water barrier 205 is smaller.

SEVENTH EMBODIMENT

Next, a landslide protection wall and method of construction thereof in accordance with the seventh embodiment will be described in detail with reference to Fig. 31.

The construction of the landslide protection wall is similar to the construction of the landslide protection wall constructed in accordance with the fourth embodiment except that the position of the guide material 202(e) differs. The construction materials which are identical to those in the fourth embodiment are numbered with the same numerals used in the description of the fourth embodiment.

As shown in Fig. 31, in the seventh embodiment, two guide materials 202(d) and 202(d) are fixed on the two sides, located on the inside of the flange 202(c) of each first soldier beam 202(a). which face the side of the excavating surface (Ga).

According to the landslide protection wall constructed as described above, because the distance between the guide materials 202(d) and 202(d) on the first soldier beam 202(a) is larger than in the sixth embodiment, the width of the sheet forming a water barrier 205 is smaller.

Claims

1. A wire saw excavator for constructing a wall forming a water barrier comprising:

two guides provided, respectively, in two guide holes in an excavation site, the guide holes extending deeper than the finished depth of the wall forming a water barrier to be constructed;

two movable pulleys each moving upward and downward along one of the two guides;

traveling means for moving the movable pulleys upward and downward along the guides, respectively;

a wire saw for excavating a ditch between the two guide holes, with the wire saw held tightly in order to pass at least once between the two moving pulleys;

a driving means for driving the wire saw; and

a grasping means for grasping a sheet which comprises the wall forming a water barrier.

2. A wire saw excavator comprising:

a driving carriage which is vertically movable along a first guide column, and which is inserted into a first guide hole excavated in the ground;

a control carriage which is vertically movable along a second guide column which is inserted into a second guide hole excavated adjacent to the first guide hole; and

a wire saw provided between the guide carriage and the control carriage for excavating the ground by the operation of the wire saw.

3. A method of construction for constructing a wall forming a water barrier using the wire saw excavator in accordance with either claim 1 or with claim 2, comprising the steps of:

excavating the ground to provide two guide holes;

excavating the ground for forming a ditch between the adjacent guide holes by operation of the wire saw;

placing impermeable material into the adjacent two guide holes and the ditch; and

making the wire saw run in order to fill the impermeable material in the ditch and guide holes.

4. A landslide protection wall constructed by using the wire saw excavator in accordance with either claim 1, or claim 2, comprising:

at least three guide holes in the same line which are disposed in an approximately vertical position, in the ground;

a ditch formed by the wire saw excavator in accordance with either claim 1 or with claim 2;

a sheet wall provided in the ditch;

soldier beams provided in each guide hole; and

sheet piles provided between each of the soldier beams;

the sheet wall comprising an impermeable sheet provided between an excavating surface of the ground and the soldier beams in the ditch, the impermeable sheet having connecting portions at both sides thereof, with each connecting portion in a guide hole; and filler provided in the ditch.

5. A construction method for constructing a landslide protection wall in accordance with claim 4 comprising the steps of:

excavating the ground for the guide holes at the location where the soldier beams are to be provided;

attaching the lower portions of the sheet to the wire saw excavator, simultaneously ex-

cavating the ditch by operation of the wire saw, and pulling the impermeable sheet into the ditch;

placing the filler into the guide holes and the ditch; and

providing the impermeable sheet pile between the soldier beams.

FIG.1(A)

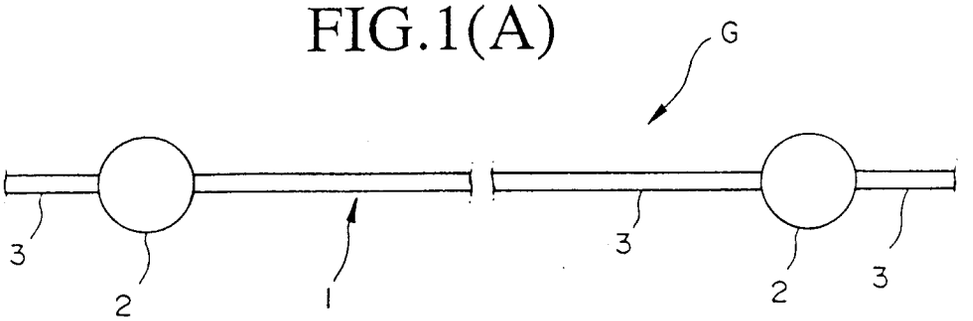


FIG.1(B)

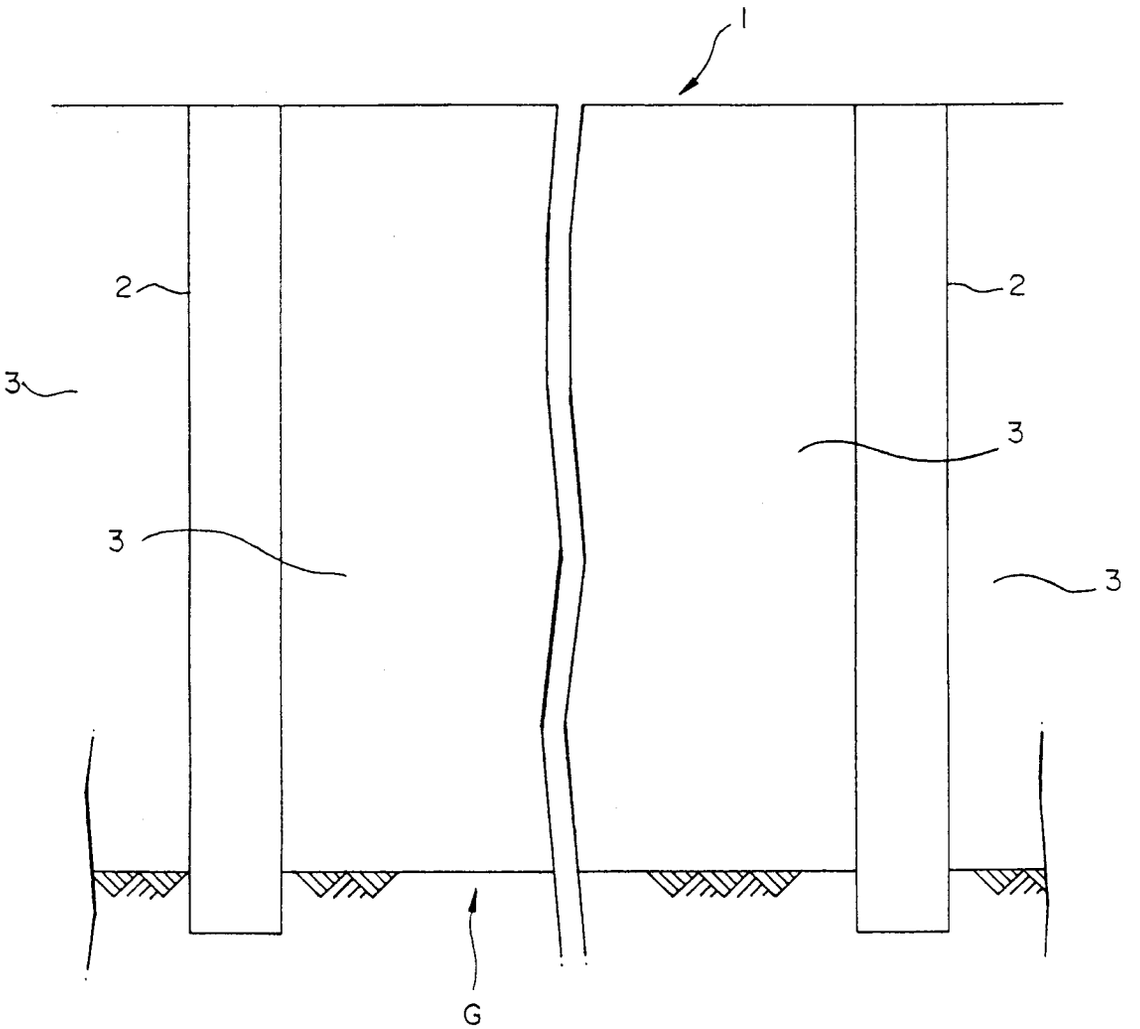
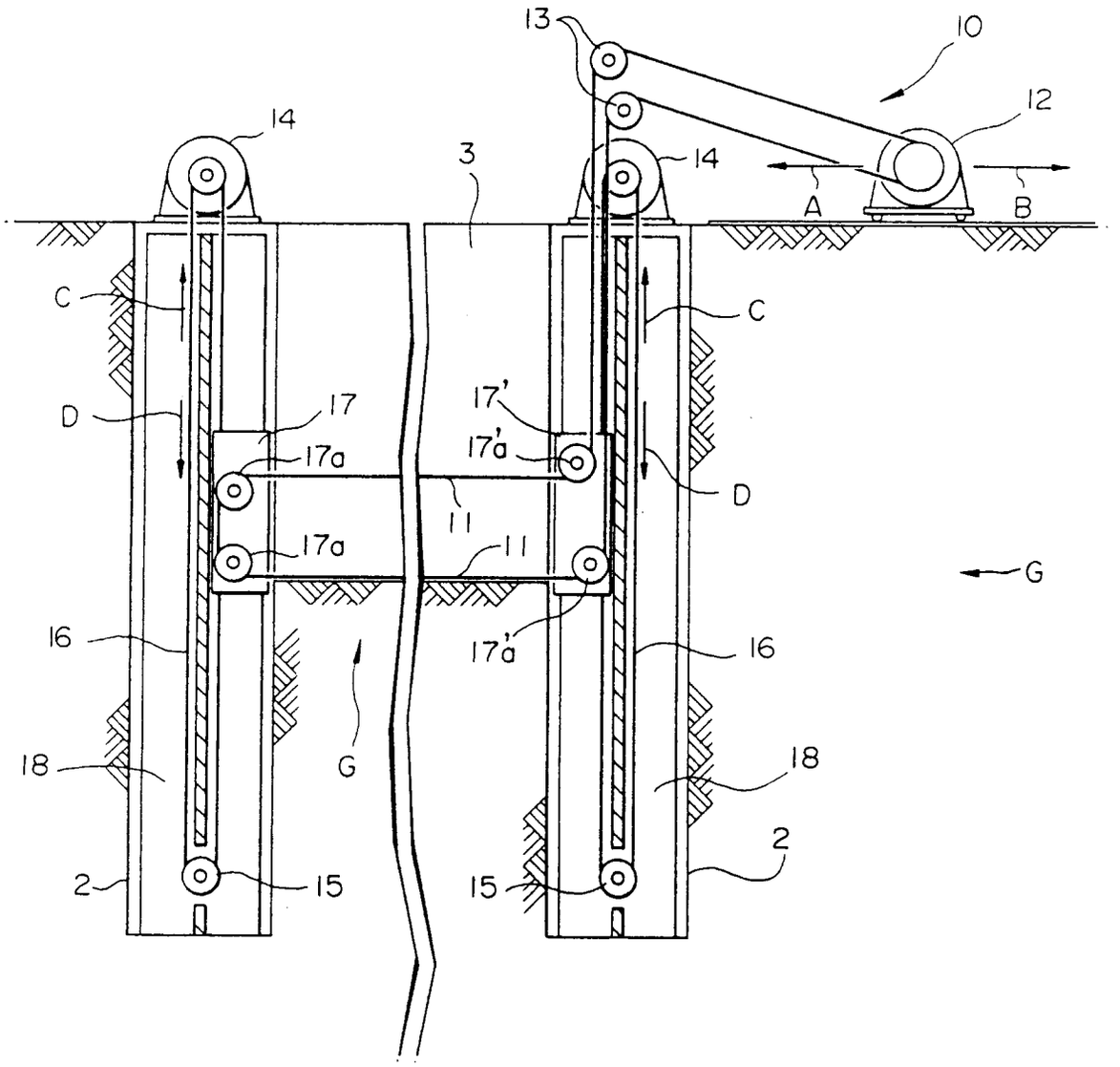


FIG.2


13
10
12
14
3
14
A
B
C
C
D
17
17'
17a
17'a
D
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17a
11
G
16
17'a
16
G
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18
2
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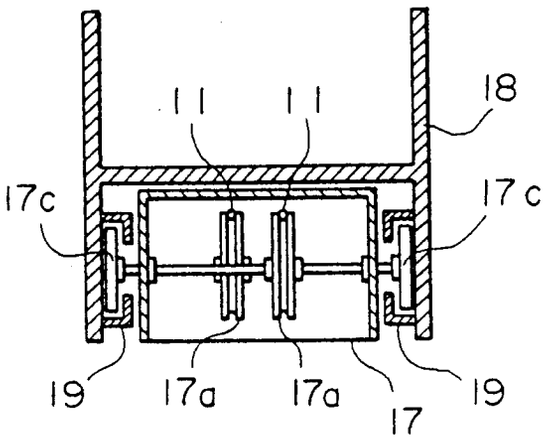
15
15

FIG.3(A)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17c
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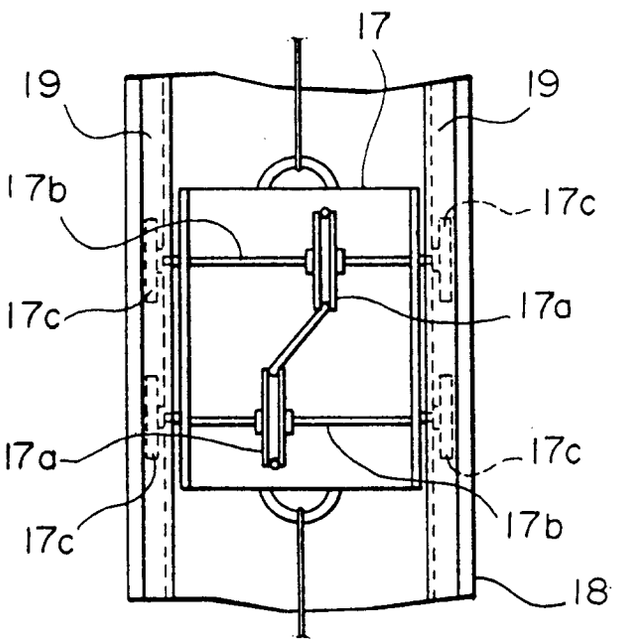
17a
17a
17
19

FIG.3(B)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17c
17b
18

FIG.4

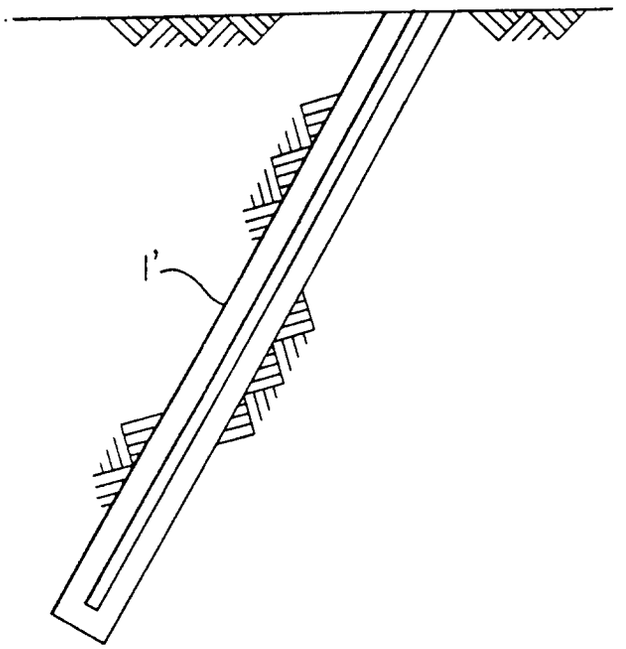


FIG.5

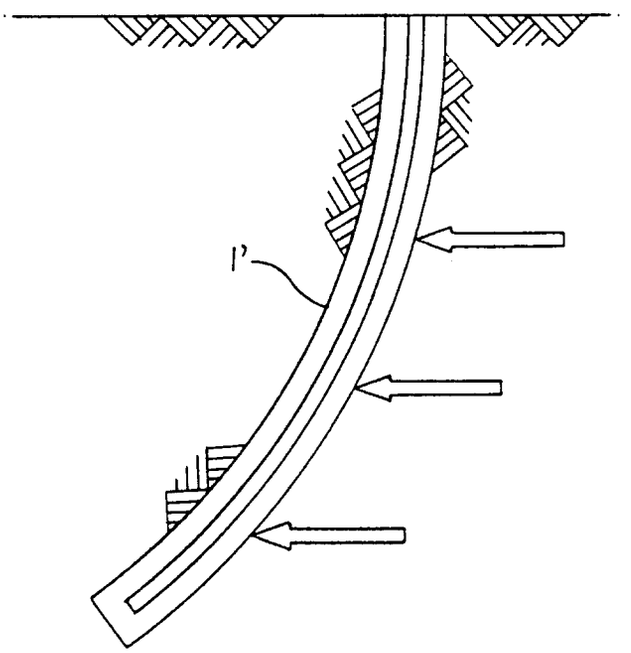
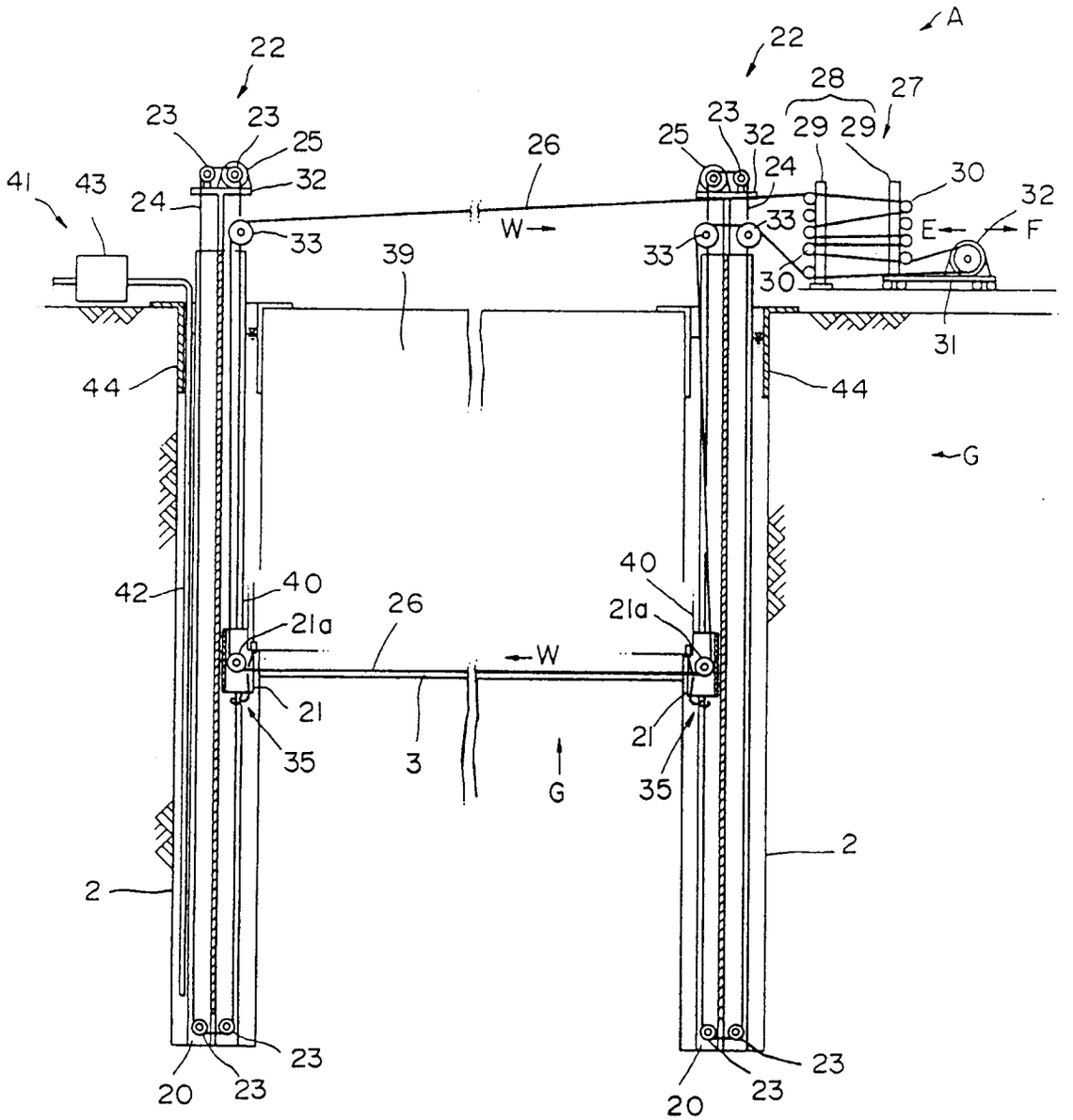


FIG.6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32
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33
W
E
F
33
33
39
30
31
44
44
G
42
40
21a
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3
G
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20
23

FIG.7

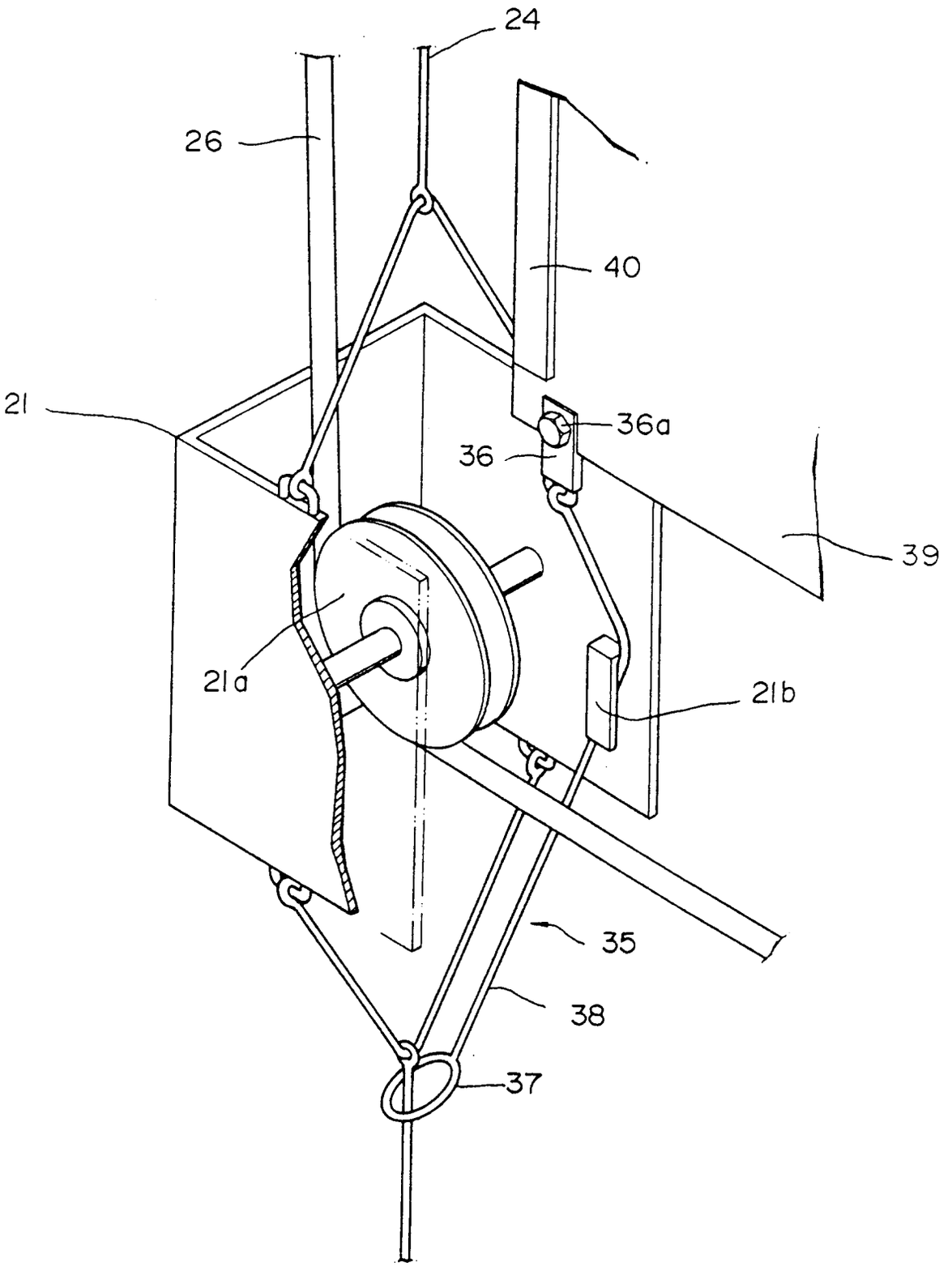


FIG.8(A)

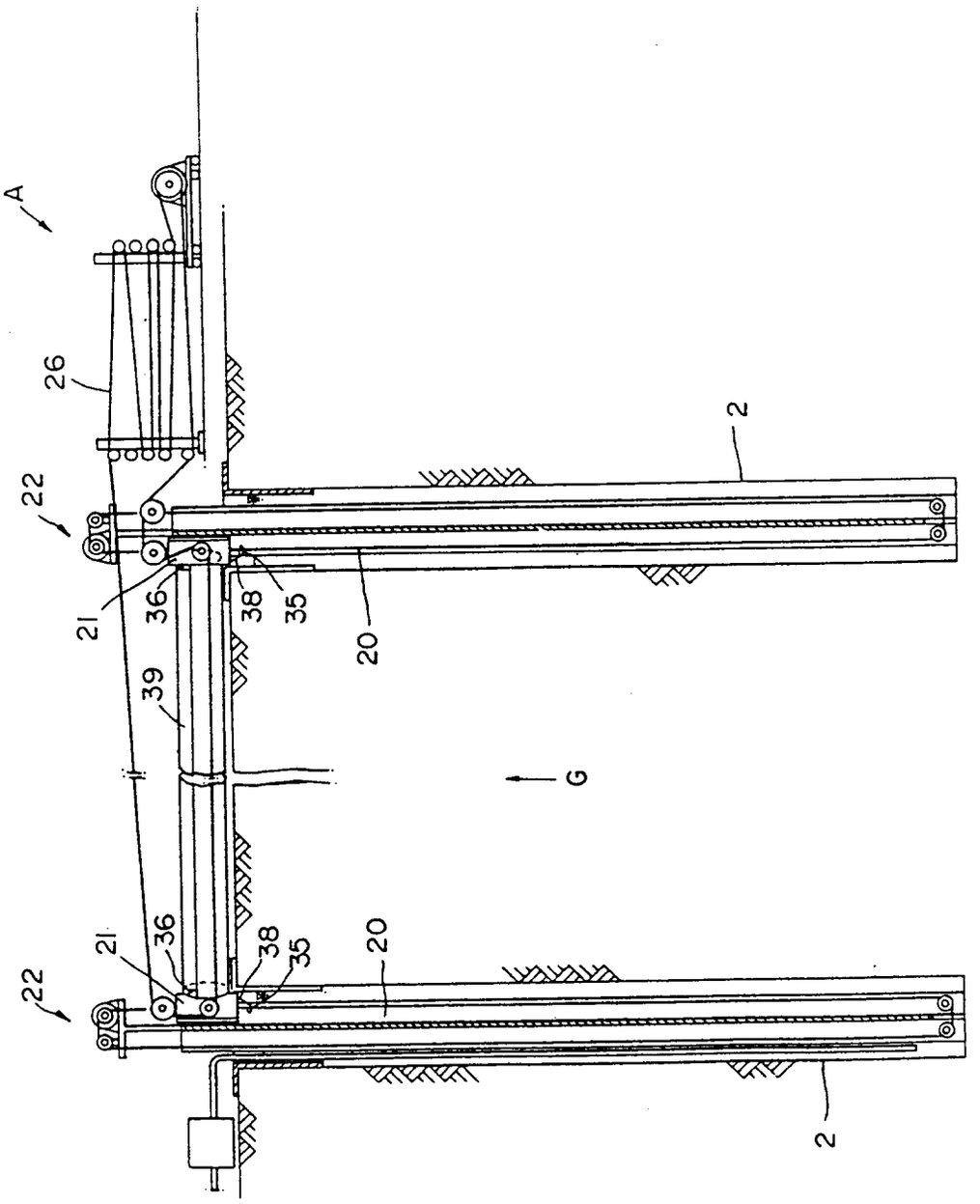


FIG.8(B)

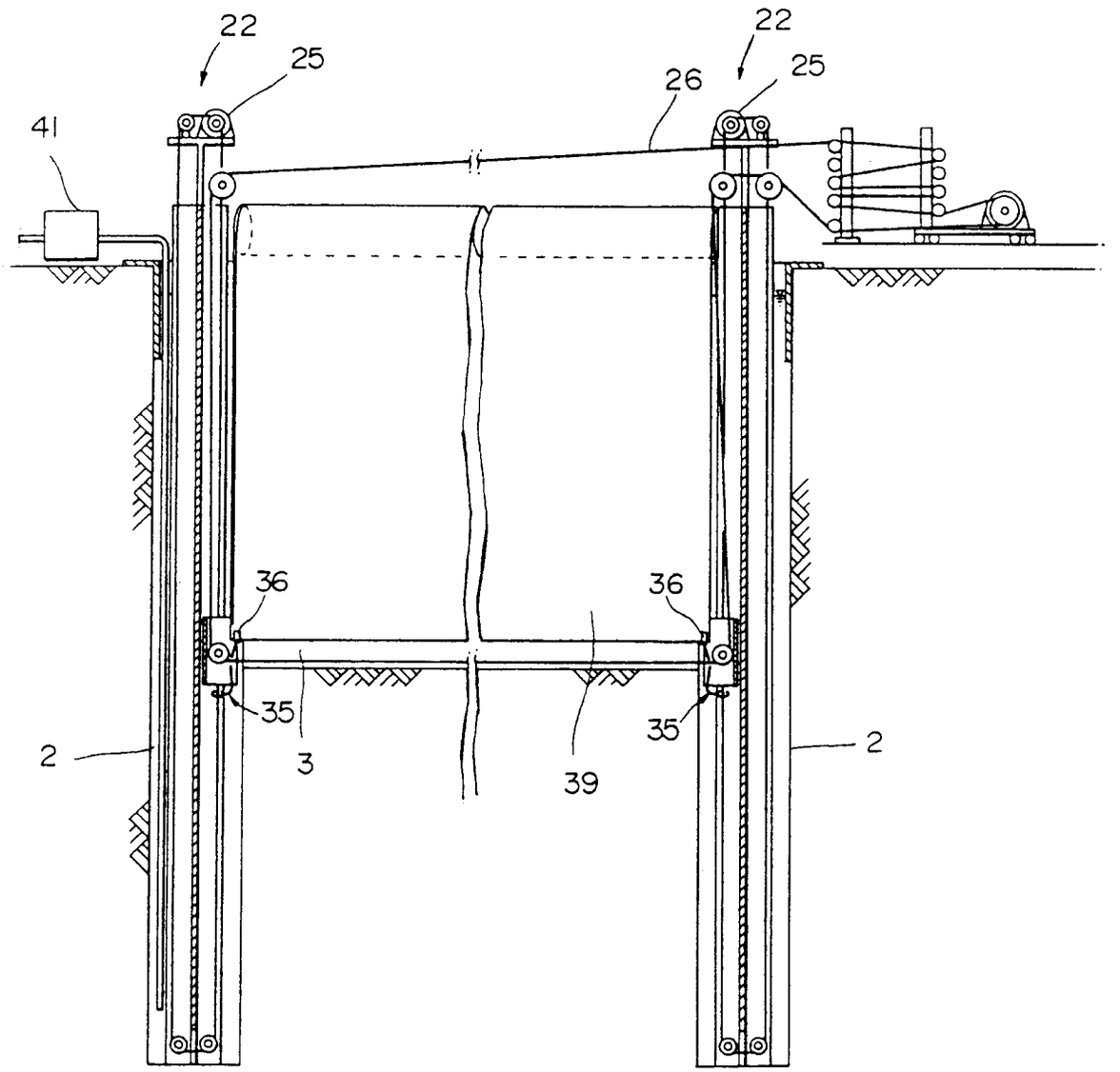


FIG.8(C)

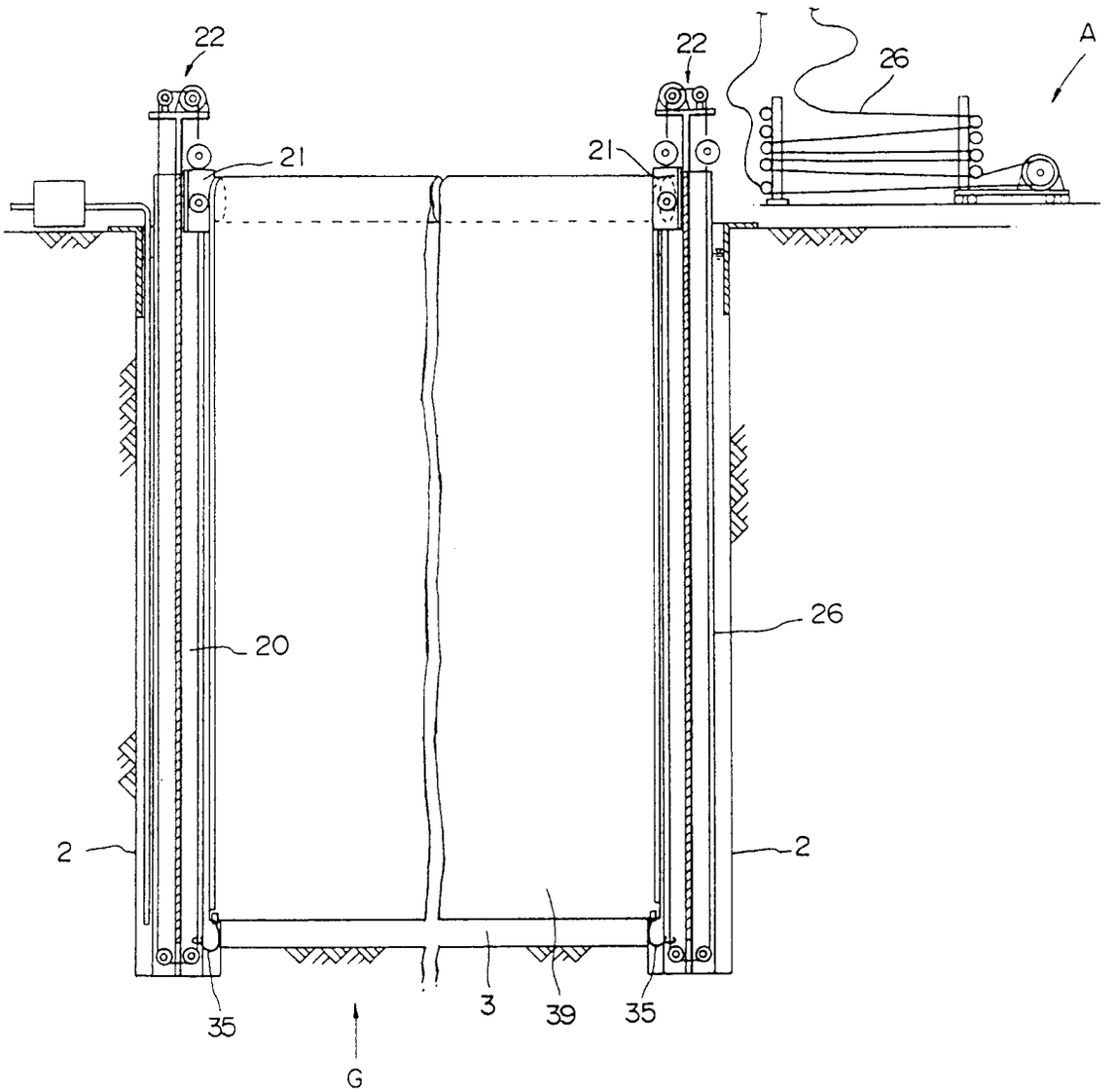


FIG.8(D)

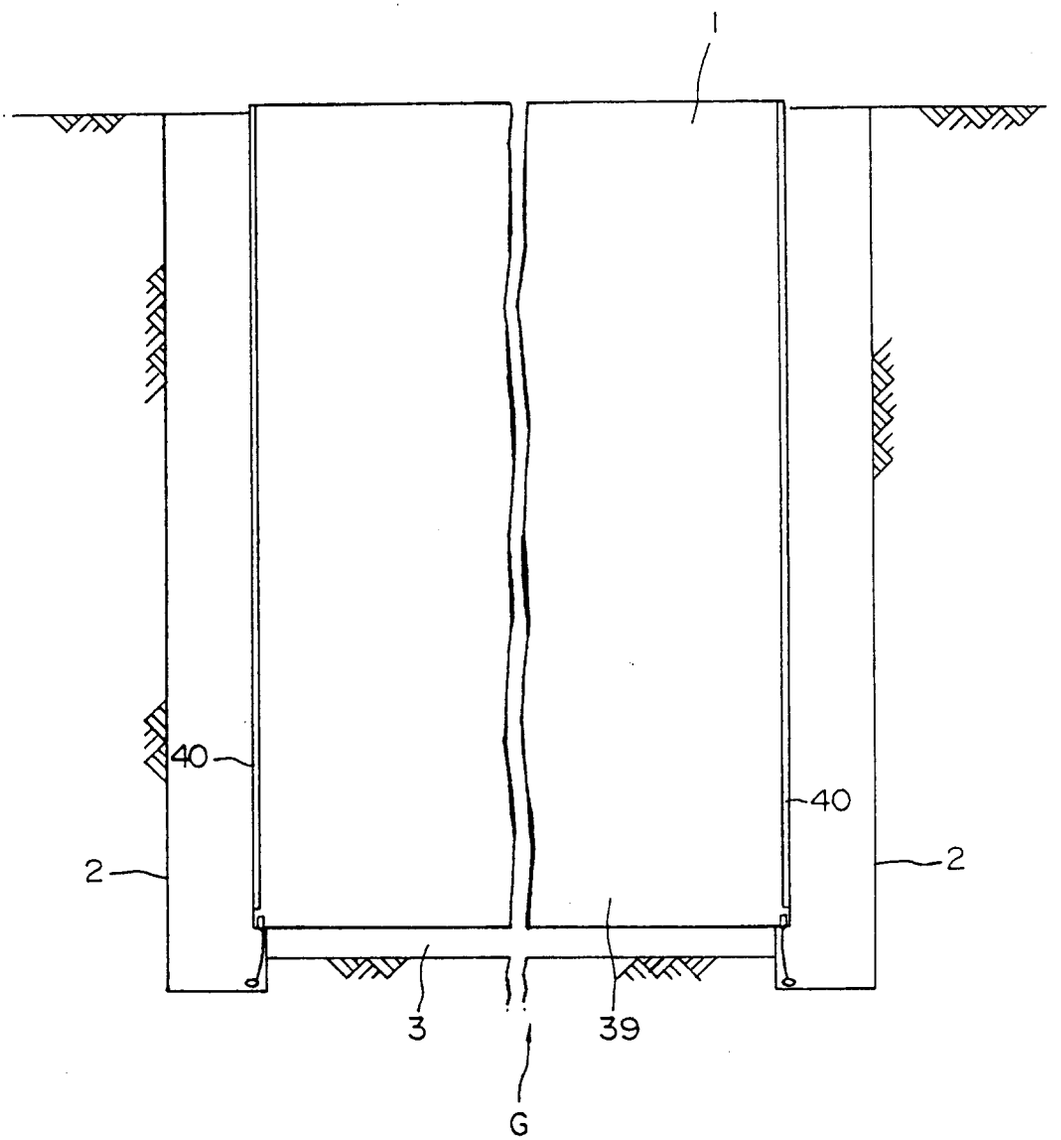


FIG.9

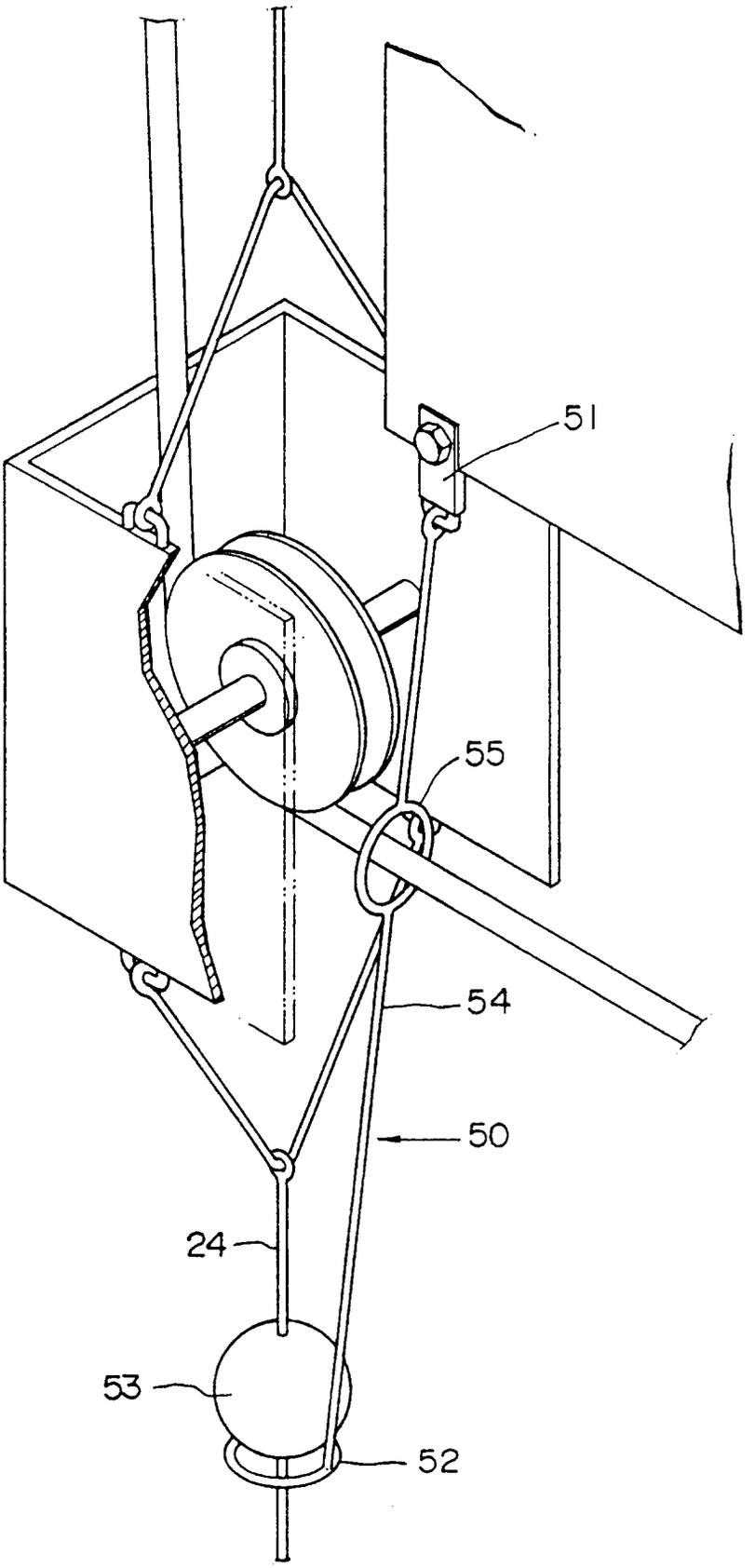


FIG.10

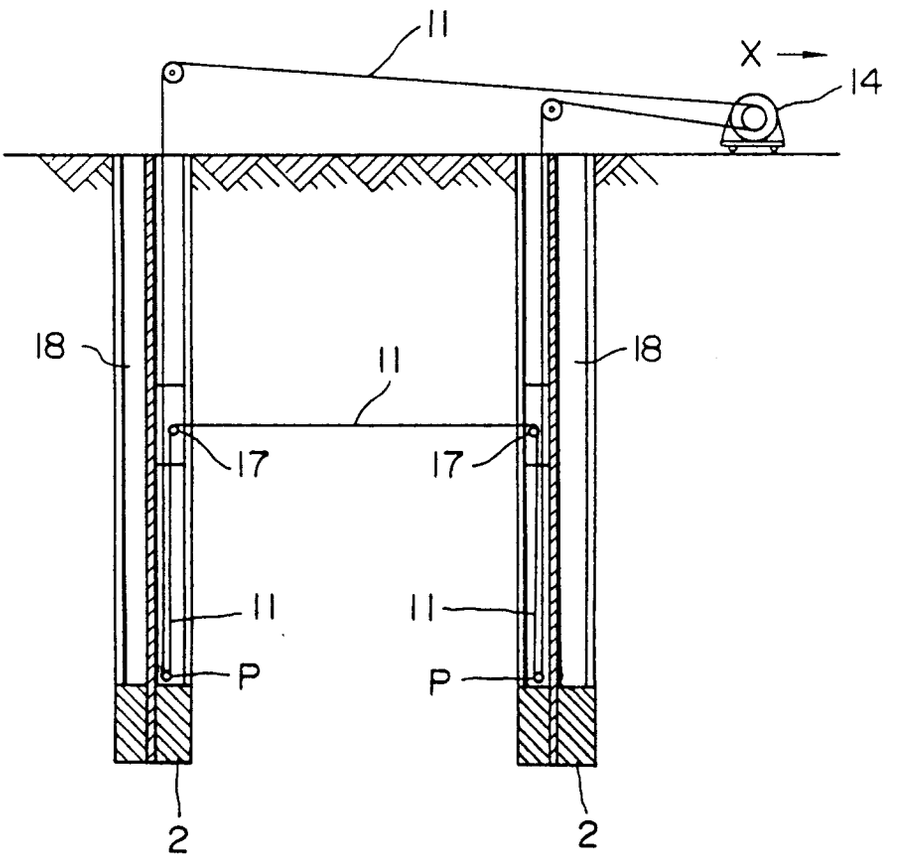
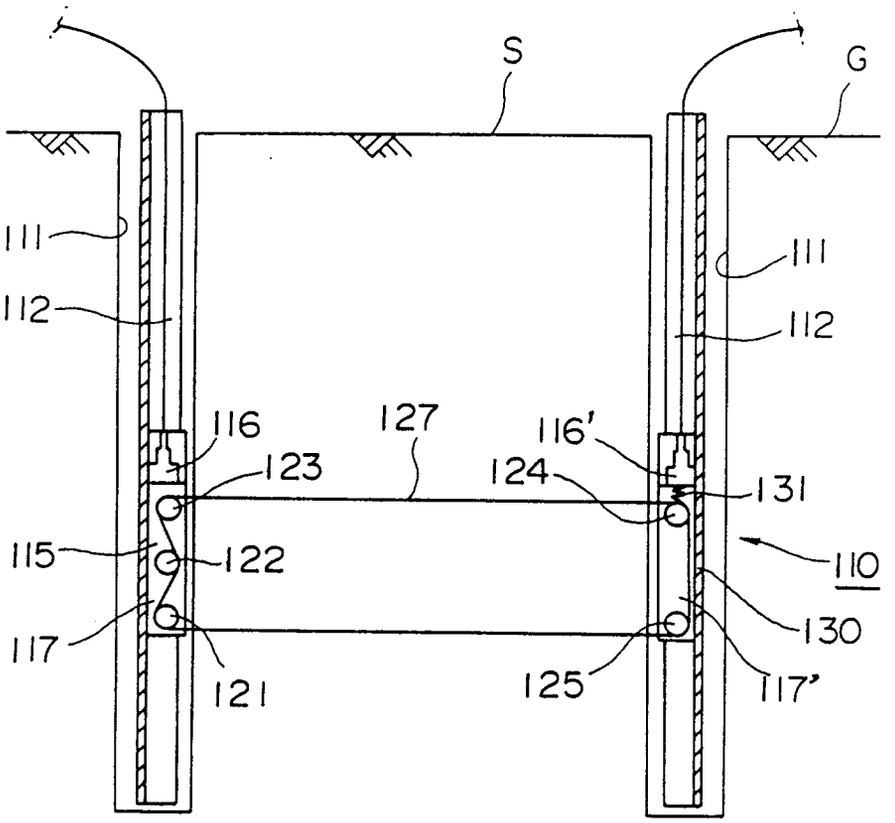


FIG.11


S
G
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112
116
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116'
123
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131
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110
117
130
121
125
117'

FIG.12

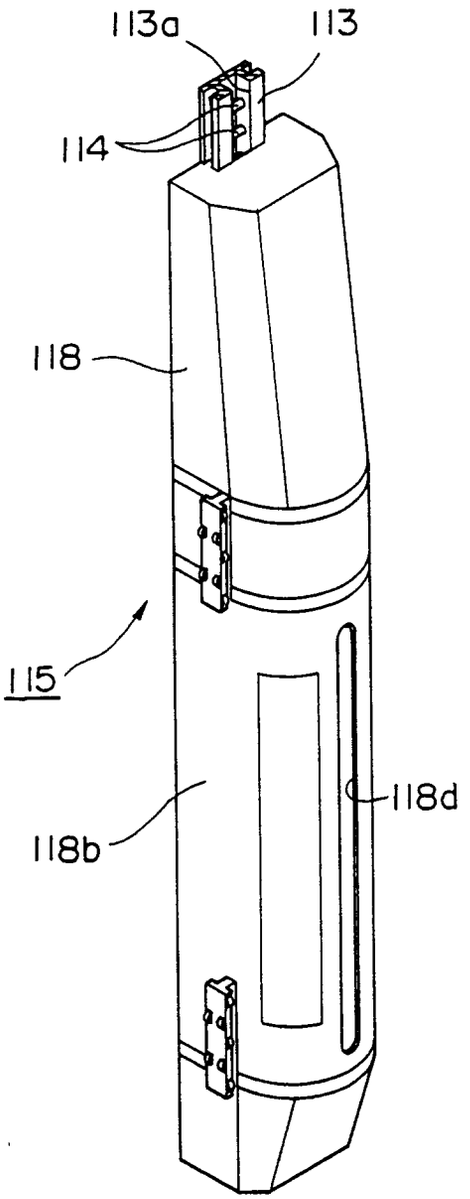

FIG.13

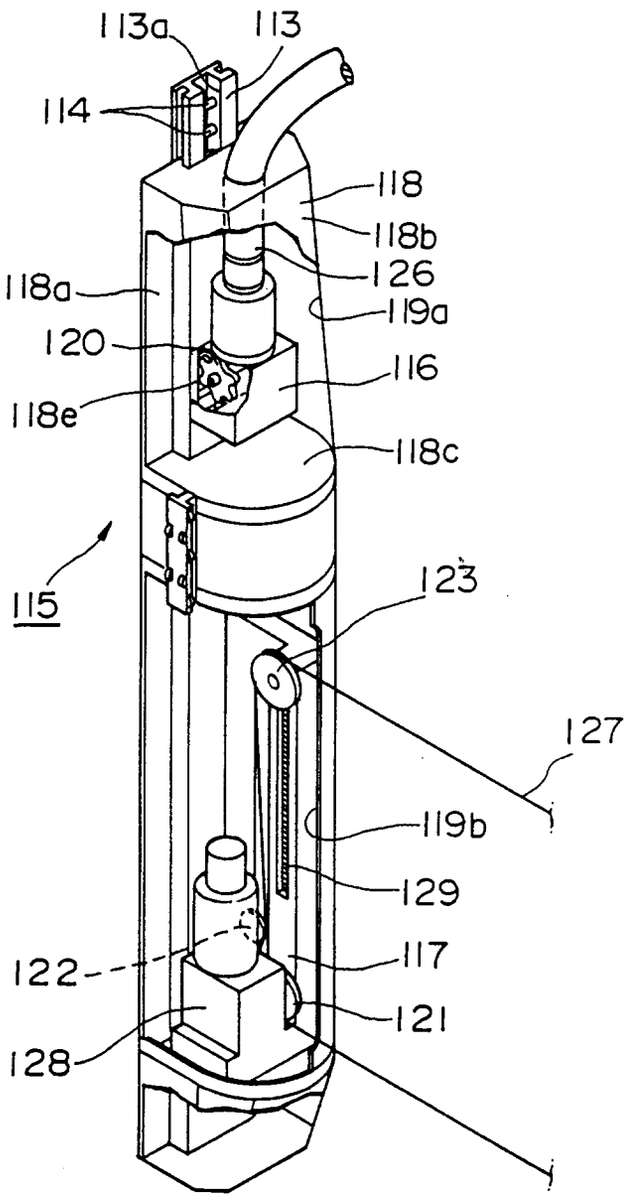
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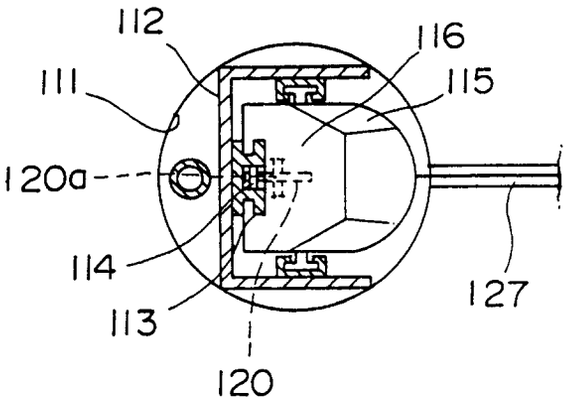
FIG.14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113
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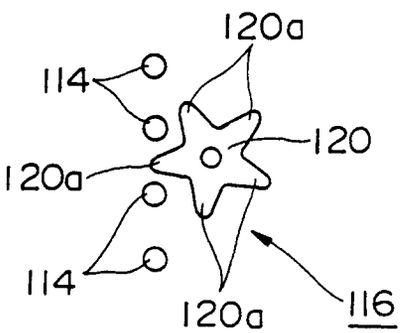
FIG.15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120a
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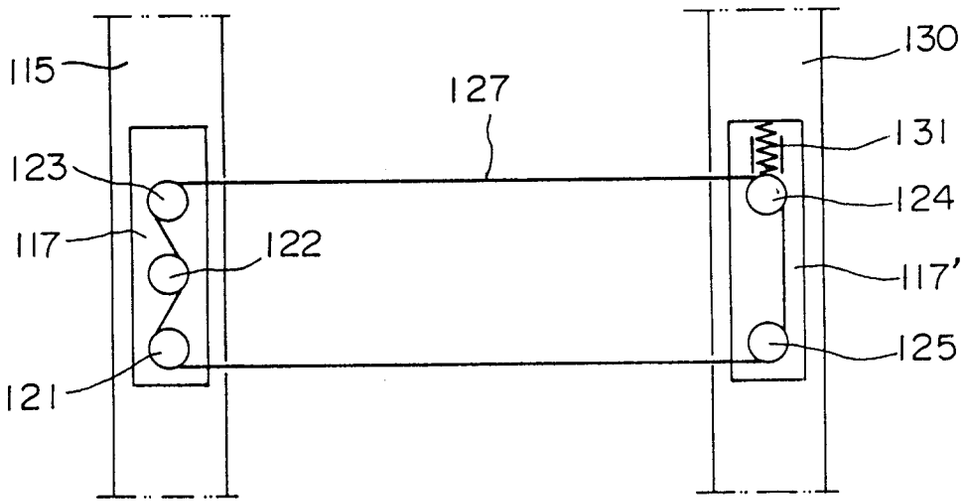
120a
116

FIG.16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117'
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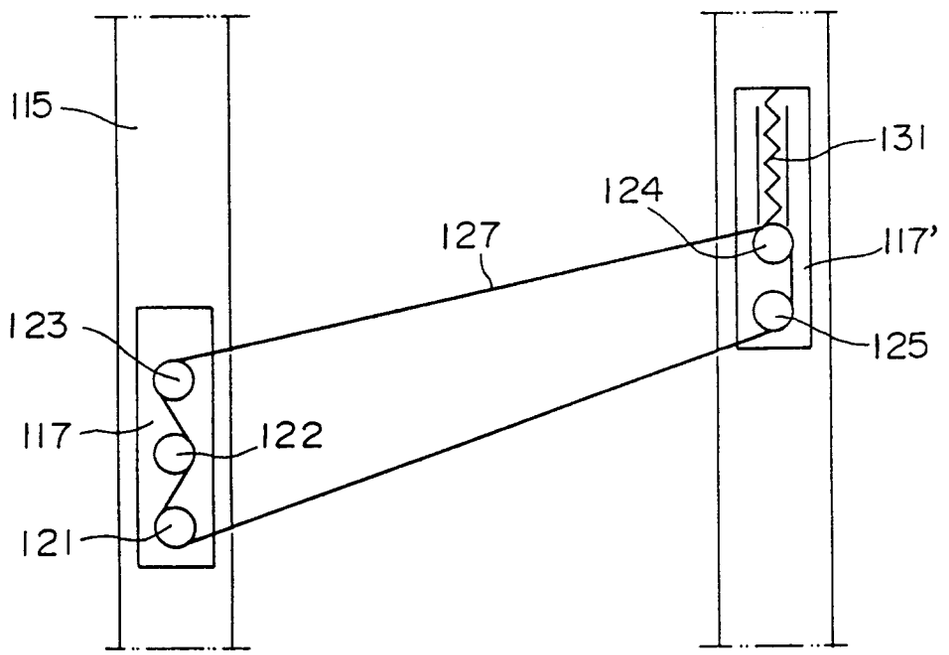
121

FIG.17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117'
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FIG.18

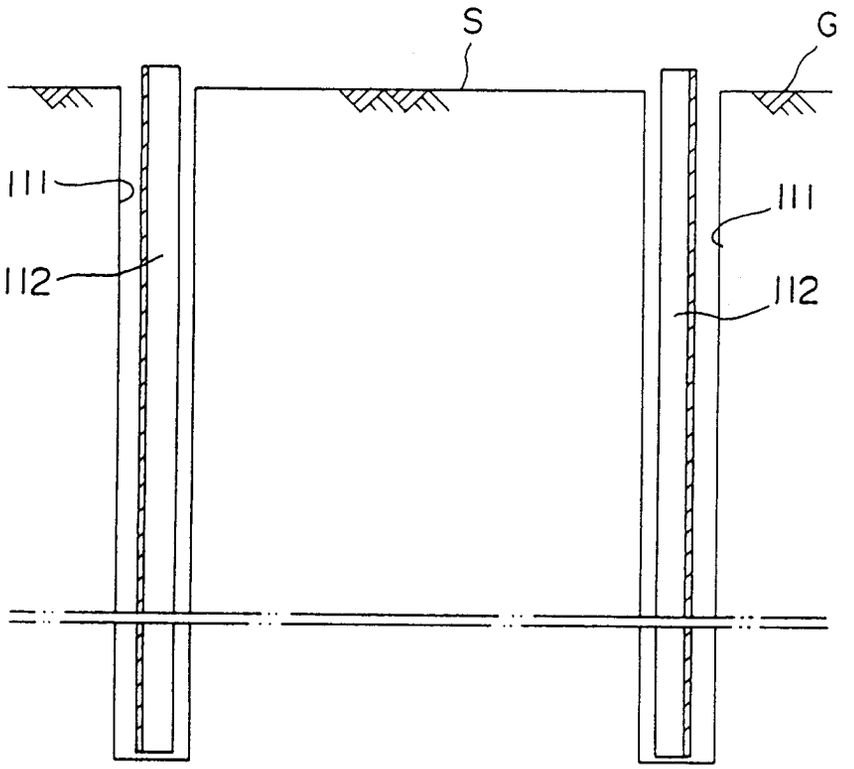


FIG.19

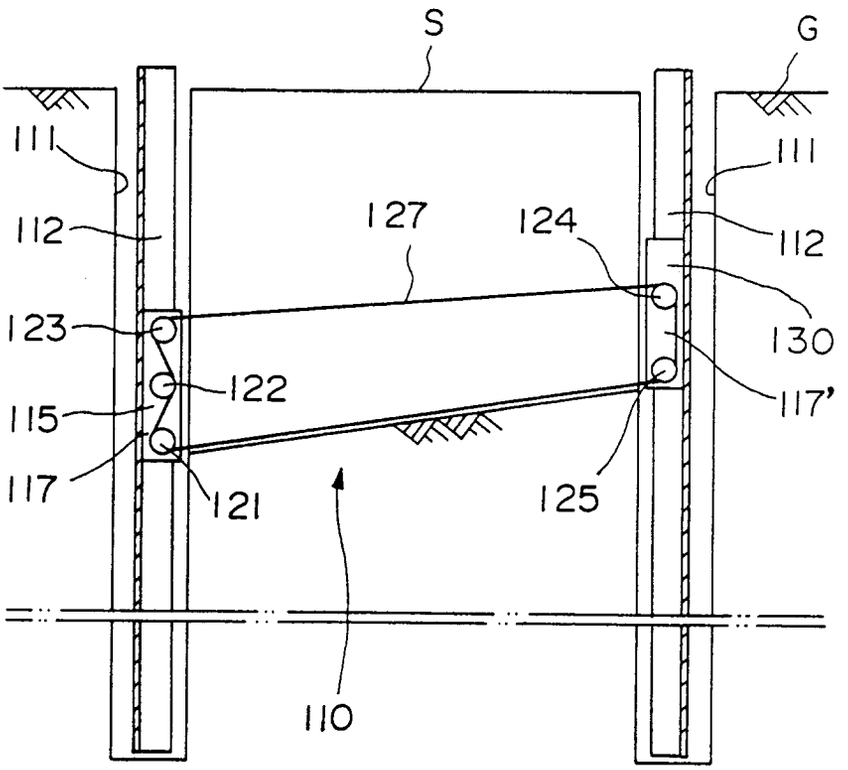


FIG.20

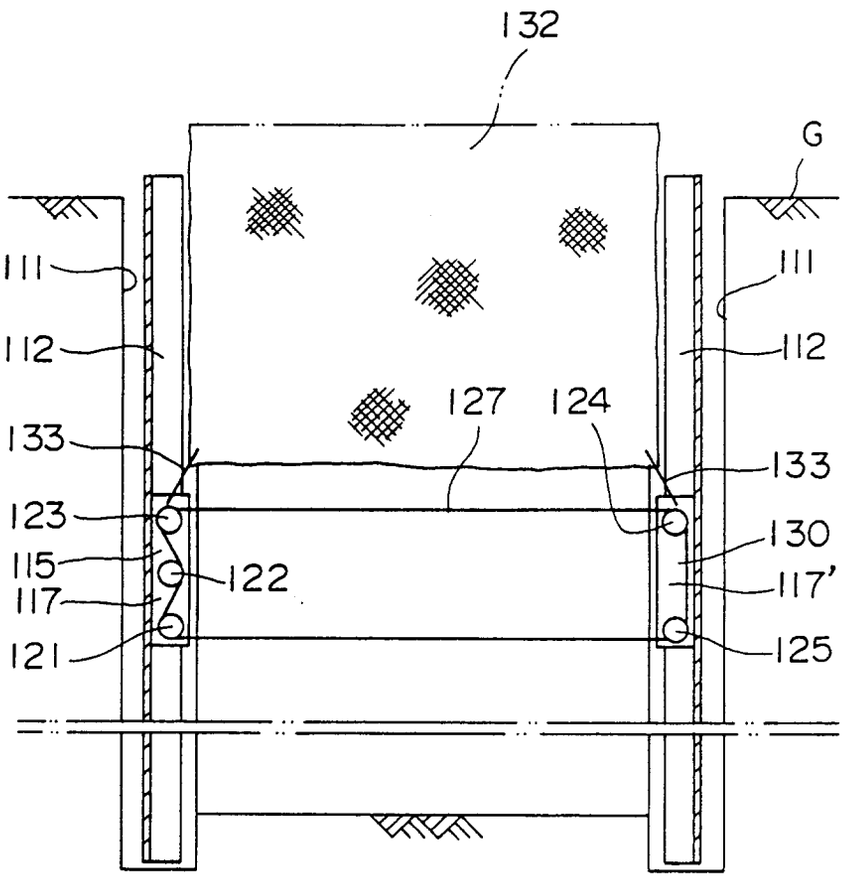
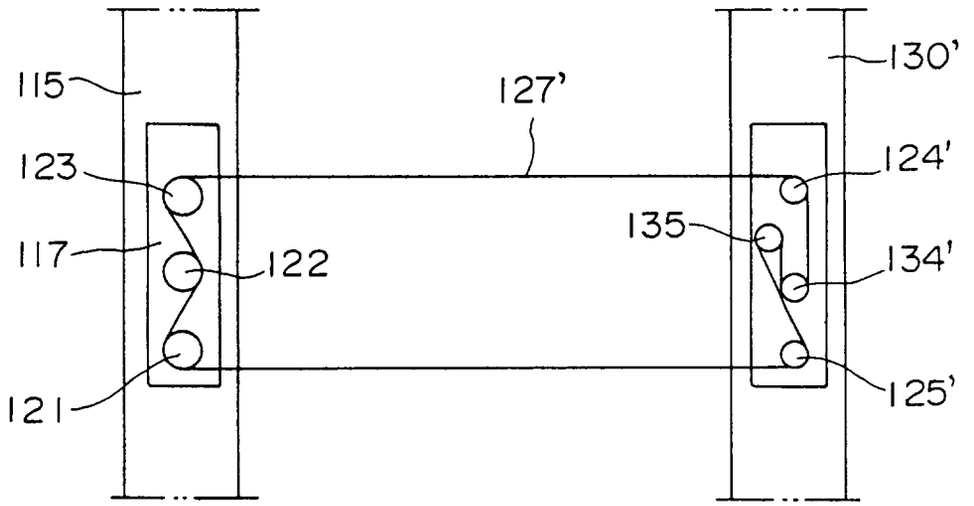


FIG.21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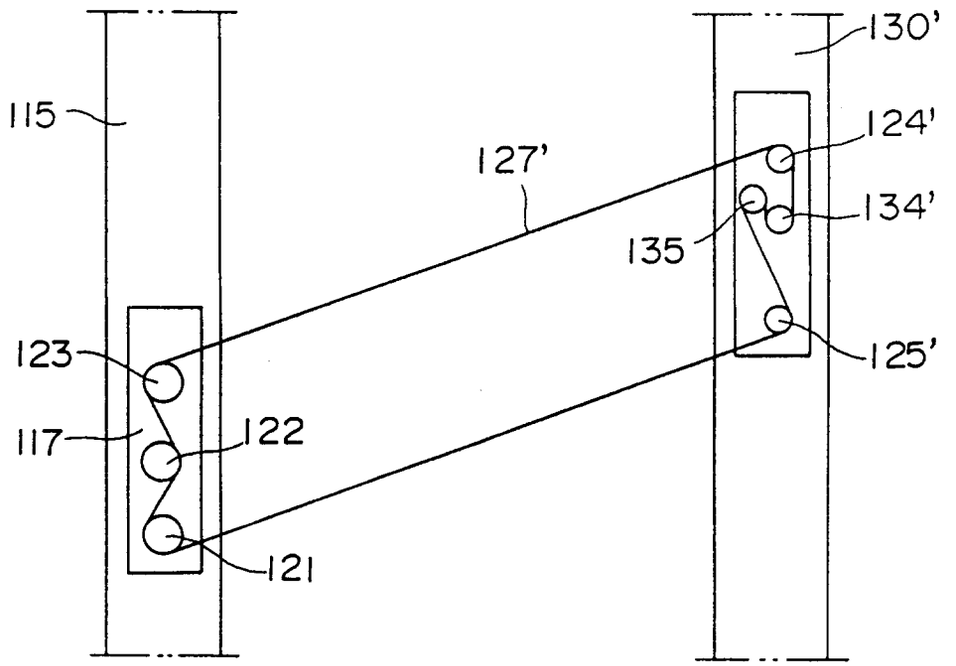
130'
123
124'
135
117
122
134'
121
125'

FIG.22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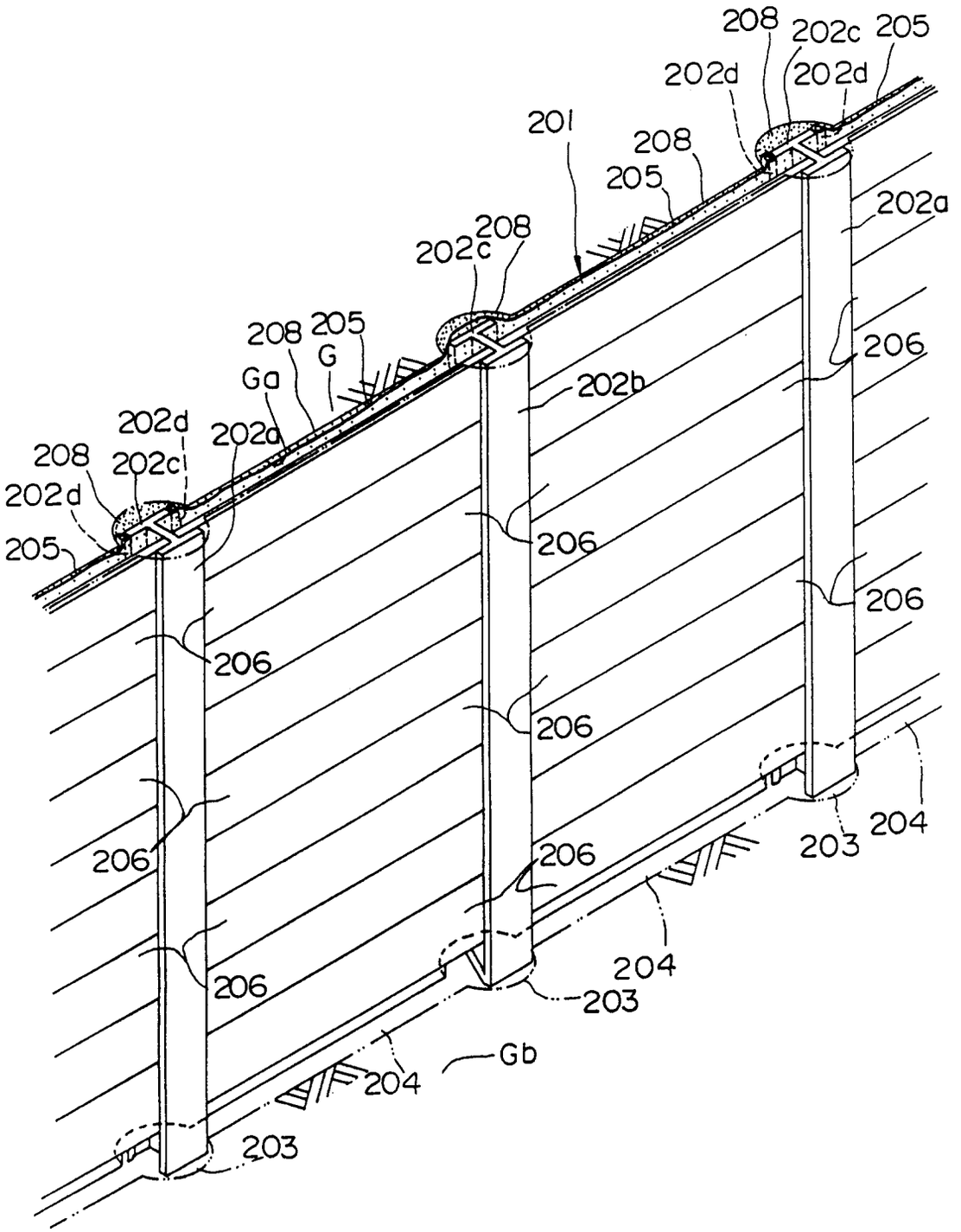
124'
127'
134'
135
123
125'
117
122
121

FIG.23


208
202c
205
202d
202d
201
208
205
202a
202c
208
208
205
G
Ga
202b
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202d
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206
206
204
203
204
Gb
204
203

FIG.24

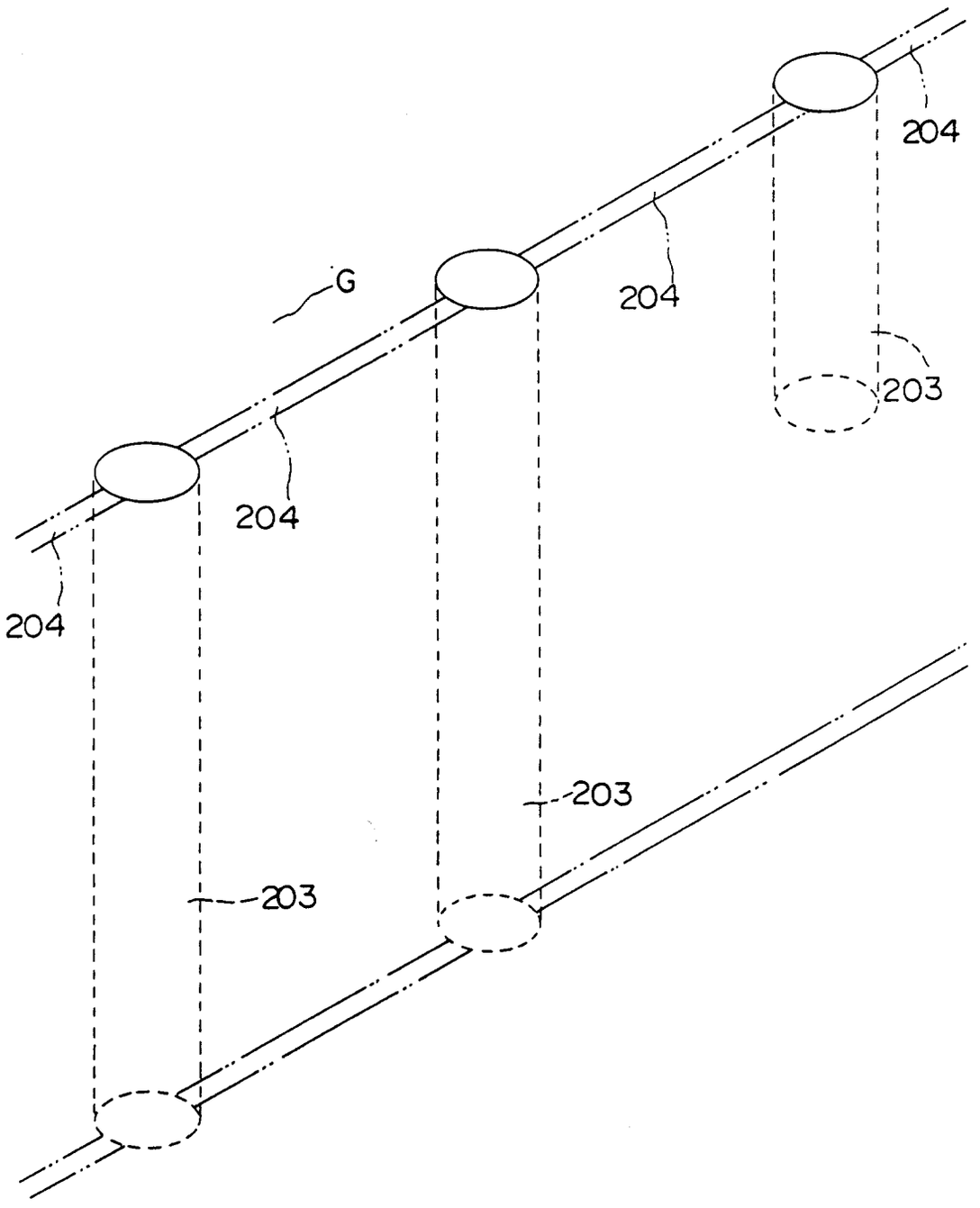


FIG.25

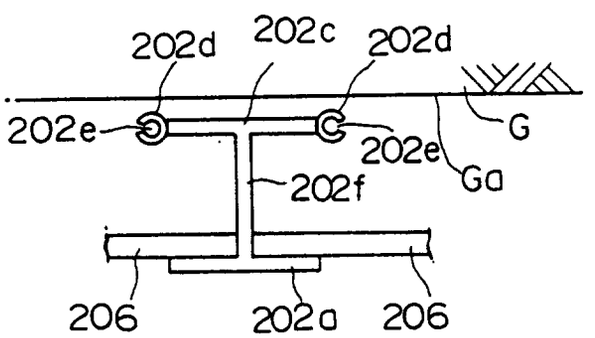


FIG.26

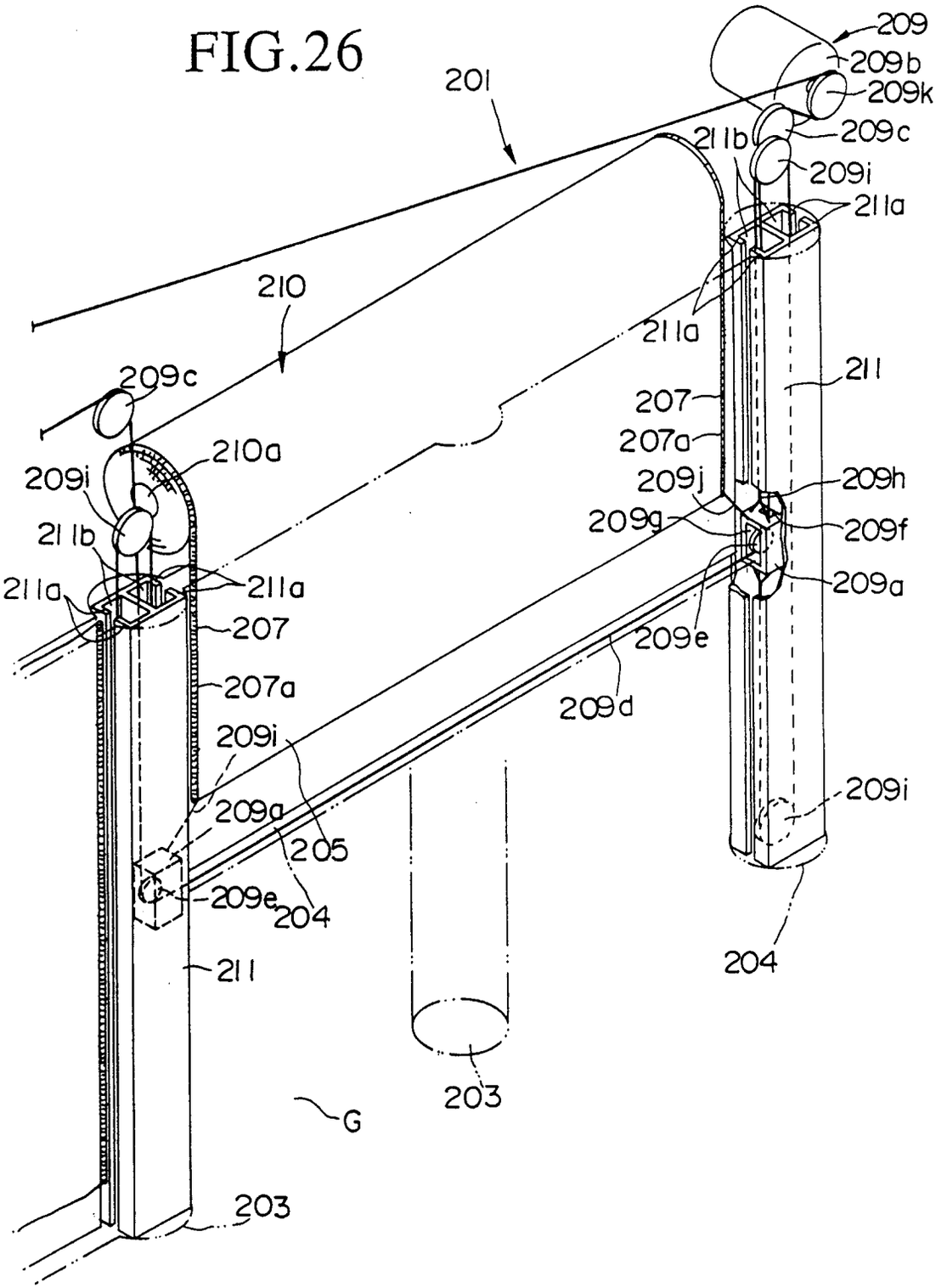

201
209
209b
209k
209c
211b
209i
211a
210
211a
209c
211
207
207a
210a
209i
209j
209h
209g
209f
211b
211a
211a
209a
207
209e
207a
209d
209i
209i
209a
205
209e
204
211
204
203
G
203

FIG.27

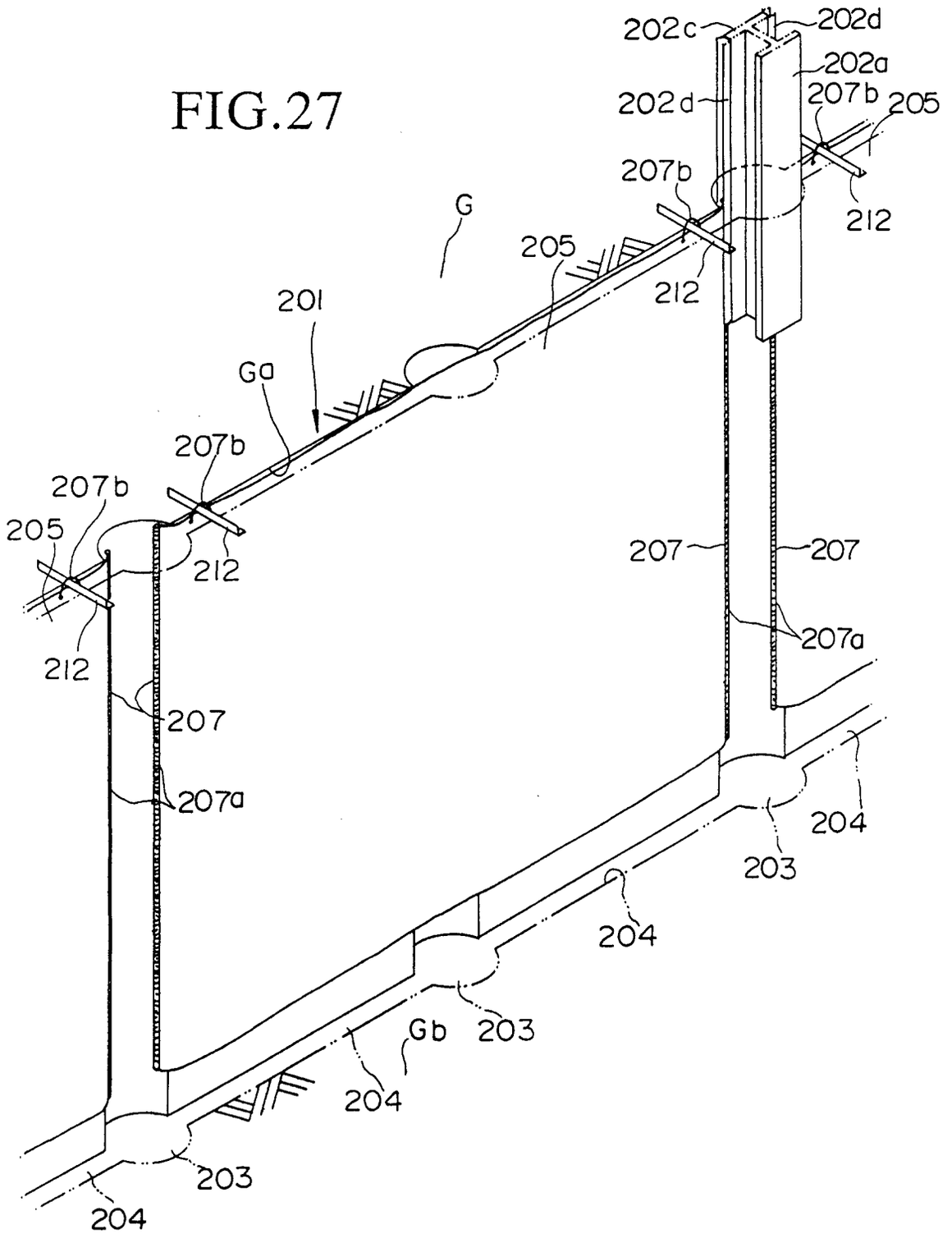

202c
202d
202a
202d
207b
205
207b
212
G
205
201
212
Ga
207b
207b
205
212
212
207
207
207a
207
207a
204
203
204
Gb
203
204
203
204

FIG.28

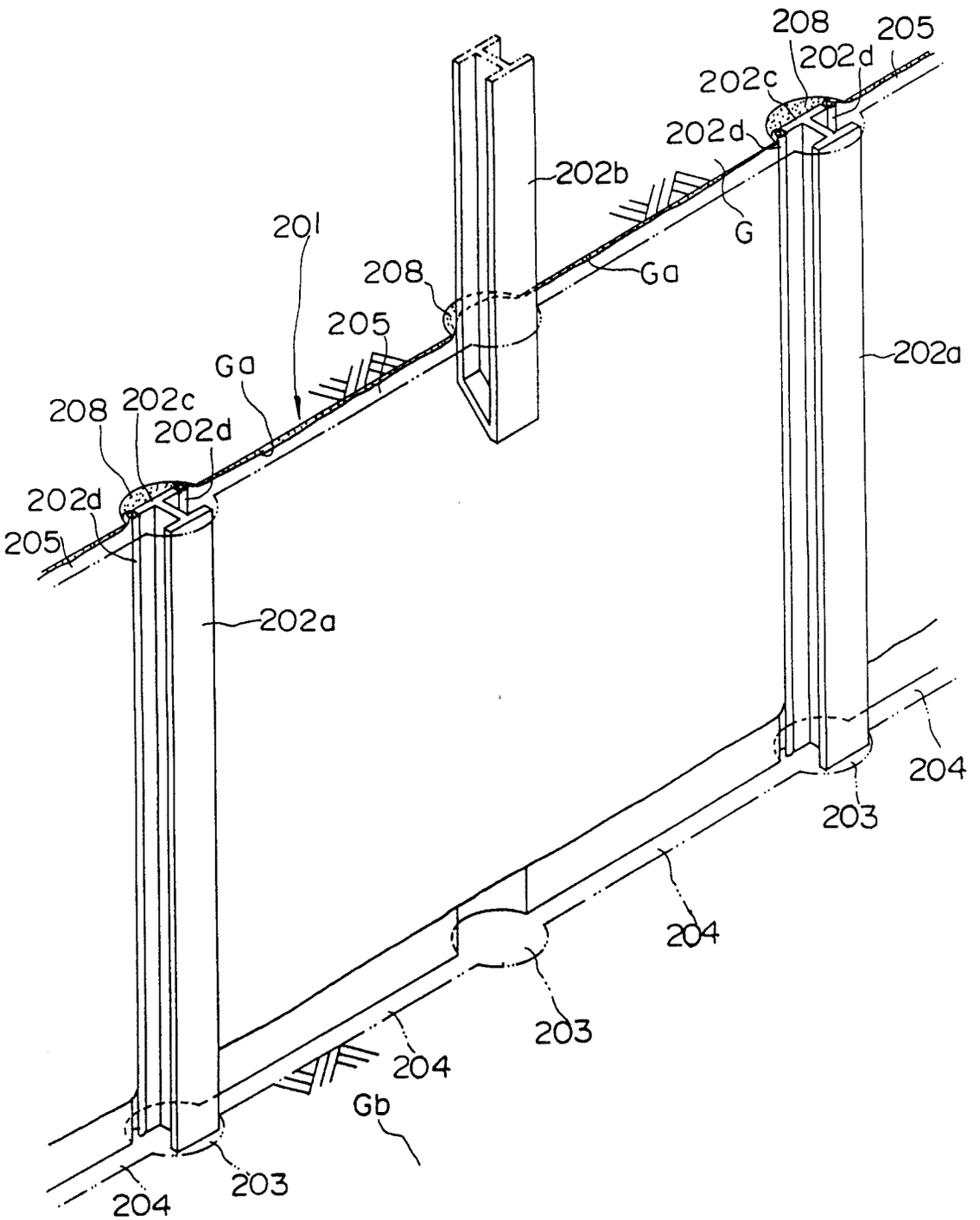

208
205
202d
202c
202d
202b
G
201
208
Ga
205
Ga
202a
208
202c
202d
202d
205
202a
204
203
204
203
204
Gb
203
204

FIG.29

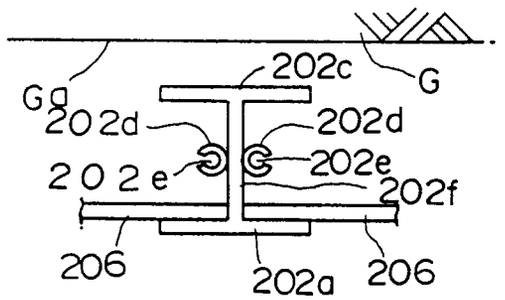


FIG.30

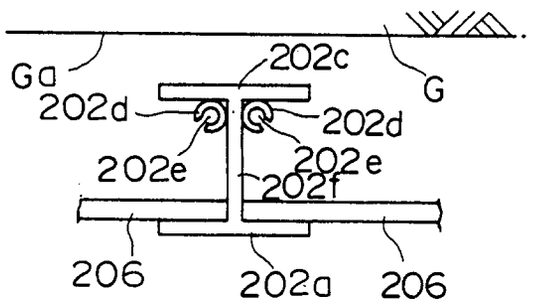
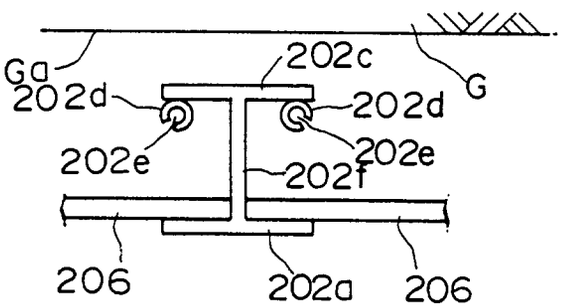


FIG.31



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP92/00062

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] E02D5/20, E02D17/13

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	E02D5/00, E02D5/18-5/20, E02D17/00-17/13

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1907 - 1992
Kokai Jitsuyo Shinan Koho	1971 - 1992

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	JP, A, 02-171412 (Toda Construction Co., Ltd.), July 3, 1990 (03. 07. 90), (Family: none)	1-5
A	JP, A, 02-171415 (Toda Construction Co., Ltd.), July 3, 1990 (03. 07. 90), (Family: none)	1-5
A	JP, A, 02-171423 (Toda Construction Co., Ltd.), July 3, 1990 (03. 07. 90), (Family: none)	1-5
A	JP, A, 02-178418 (Okumuragumi K.K.), July 11, 1990 (11. 07. 90), (Family: none)	1-5

* Special categories of cited documents: [10]

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

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

"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

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
February 15, 1992 (15. 02. 92)	February 25, 1992 (25. 02. 92)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	