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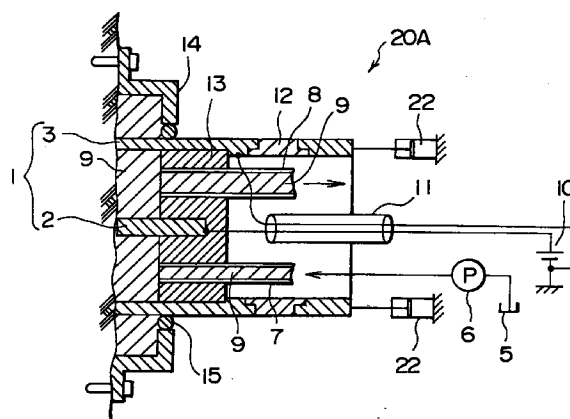
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(54) **UNDERGROUND AUGERING MACHINE BY ELECTRICAL CRUSHING, EXCAVATOR, AND ITS EXCAVATING METHOD**

(57) The invention relates to an underground augering machine by an electrical crushing provided with a mechanism which can surely retain a solution around electrodes for electrical crushing, an excavator, and its excavating method. Accordingly, there is provided at least a pair of electrodes (1) for electrical crushing provided on a front face of the underground augering machine, a pulse generator (10) for applying a high-voltage pulse between the electrodes (1), a solution (9) filling up a space around the electrodes, a solution retaining cover (14) retaining the solution around the electrodes between the front face of the augering machine and the ground and provided on the outer peripheral surface of the augering machine, a solution feeding pipe (7) for feeding the solution to a peripheral portion of the electrodes, a pump (6) for supplying the solution to the front face of the augering machine through the solution feeding pipe and a storage tank (5) for storing the solution. Further, there may be provided a case (19) retaining the solution around the electrodes between the front face of the excavator and the ground and provided in the periphery of the electrodes.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to an underground augering machine by an electrical crushing, an excavator, and its excavating method, which efficiently retains a solution around electrodes for an electrical crushing by means of a pulse electrical energy discharge so as to excavate.

BACKGROUND ART

[0002] Conventionally, there have been suggested some methods for crushing a rock bed, a concrete and the like by a discharge of an electrical energy (hereinafter, refer to an electrical crushing).

[0003] For example, in Japanese Unexamined Patent Publication No. 4-222794, a hole is formed in a solid insulating material such as a rock and the like by a drill and the like, coaxial electrodes are inserted into the hole in a state of receiving an electrolytic solution having a viscosity (for example, a copper sulfate electrolytic solution within the hole, and a high-voltage pulse is applied to the electrodes. Accordingly, a plasma discharge is generated between the electrodes, and an electrical energy discharged at this time crushes the rock so as to separate into pieces. Further, the structure is made such that a closed area around the electrodes is filled with the electrolytic solution, thereby increasing a breaking force generated by the plasma discharge. Still further, the structure is made such that a time for increasing the high-voltage pulse is made smaller than a predetermined value, so that a discharge current can easily flow within a solid insulating material.

[0004] In such an electrical crushing, it is important to retain the electrolytic solution in the closed area around the electrodes in order to increase the crushing energy. It is also disclosed that the electrolytic solution is combined with a gelatinizer such as a bentonite or a gelatin, thereby applying a sufficient viscosity so that the electrolytic solution does not flow out. Accordingly, in the case of excavating a vertical hole and crushing in a state that the hole is filled with the electrolytic solution, it is possible to retain the electrolytic solution if the electrolytic solution is supplemented at a certain amount for permeating the material. However, there is not disclosed a method for retaining the electrolytic solution in a horizontal hole, and it is hard to retain by the conventional method.

[0005] Here, in the case of applying the electrical crushing technique to a machine for crushing and excavating the rock bed, the concrete or the like, the crushing and excavating with using the horizontal hole is very important function for widening an applicable range. Accordingly, it is strongly desired to develop a technique for efficiently retaining a solution such as the electrolytic solution and the like in the horizontal hole.

DISCLOSURE OF THE INVENTION

[0006] The present invention is made by taking the problems mentioned above into consideration, and an object of the present invention is to provide an underground augering machine by an electrical crushing provided with a mechanism which can surely and efficiently retain a solution such as an electrolytic solution and the like around electrodes for electrical crushing, an excavator, and its excavating method.

[0007] In accordance with a first aspect of the present invention, there is provided an underground augering machine comprising:

- at least a pair of electrodes for electrical crushing provided on a front face of the underground augering machine;
- a pulse generator for applying a high-voltage pulse between the electrodes;
- a solution filling up a space around the electrodes;
- a solution retaining cover provided on an outer peripheral surface of the augering machine and retaining the solution around the electrodes between the front face of the augering machine and the ground;
- a solution feeding pipe for feeding the solution to a peripheral portion of the electrodes;
- a pump for supplying the solution to the front face of the augering machine through the solution feeding pipe; and
- a storage tank for storing the solution and being sucked up the solution by the pump, wherein the high-voltage pulse is discharged between the electrodes so as to excavate under the ground.

[0008] In accordance with the structure mentioned above, it is structured such that the solution in the storage tank is sucked up by the pump and is fed to the periphery of the electrodes on the front face through the solution feeding pipe at a predetermined pressure. The solution is prevented from flowing out by the solution retaining cover provided on the outer peripheral surface of the underground augering machine. Accordingly, since the solution around the electrodes is retained in a pressurized state, the discharge energy in the electrodes can be efficiently utilized for excavating. In this case, when the solution having a high viscosity is used, a leakage of the solution can be further reduced, so that a solution retaining effect can be improved.

[0009] In accordance with a second aspect of the present invention, there is provided an underground augering machine comprising:

- at least a pair of electrodes for electrical crushing provided on a front face of the underground augering machine;
- a pulse generator for applying a high-voltage pulse between the electrodes;

a solution filling up a space around the electrodes;
 a case provided around the electrodes and retaining the solution around the electrodes between the front face of the augering machine and the ground;
 a solution feeding pipe for feeding the solution to a peripheral portion of the electrodes;
 a pump for supplying the solution to the front face of the augering machine through the solution feeding pipe; and
 a storage tank for storing the solution and being sucked up the solution by the pump, wherein the high-voltage pulse is discharged between the electrodes so as to excavate under the ground.

[0010] In accordance with the structure mentioned above, it is structured such that the solution in the storage tank is sucked up by the pump and is fed to the periphery of the electrodes on the front face through the solution feeding pipe at a predetermined pressure. At this time, since the solution around the electrodes is retained between the urging machine and the ground by the case, it is possible to prevent the solution from flowing out. Accordingly, since the solution around the electrodes is retained in a pressurized state, the discharge energy in the electrodes can be efficiently utilized for excavating. In this case, when the solution having a high viscosity is used, a leakage of the solution can be further reduced, so that a solution retaining effect can be improved.

[0011] In accordance with a third aspect of the present invention, there is provided an underground augering machine as cited in the first or second aspect, in which the at least one pair of electrodes comprise an outer peripheral electrode which is similar to a shape of the hole to be excavated and an inner electrode which is arranged in a center portion of the outer peripheral electrode.

[0012] Accordingly, since the shape of the outer peripheral electrode is formed in such a manner as to be similar to the shape of the hole to be excavated, the outer peripheral portion is formed as one of a pair of electrodes and the other electrode is arranged in the center portion thereof, a hole having a desired shape can be excavated by the electrical crushing. Therefore, an efficient underground augering can be performed.

[0013] In accordance with a fourth aspect of the present invention, there is provided an underground augering machine as cited in the first or second aspect, in which a solution retaining member for retaining the solution is provided in such a manner as to fill up the periphery of the electrodes.

[0014] Accordingly, the solution around the electrodes can be absorbed and retained by the solution retaining member. Therefore, the discharge energy in the electrodes can be efficiently utilized for excavating, so that an efficient underground augering can be performed.

[0015] In accordance with a fifth aspect of the present invention, there is provided an underground augering

machine as cited in the first or second aspect, in which a continuous soil discharging mechanism for continuously discharging soils and the like crushed and excavated by the electrodes is provided.

[0016] Accordingly, since the soils and the like electrically crushed are discharged by the continuous soil discharging mechanism, an efficient underground augering can be performed.

[0017] In accordance with a sixth aspect of the present invention, there is provided an underground augering machine as cited in the second aspect, in which the case constitutes any one of a positive electrode or a negative electrode of the at least one pair of electrodes.

[0018] Accordingly, any one of the positive electrode or the negative electrode of the electrodes in the outer peripheral portion has the same function as that of the case for retaining the solution. Therefore, a structure can be simplified.

[0019] In accordance with a seventh aspect of the present invention, there is provided an excavator having a lower traveling body structured such as to freely travel, a vehicle body provided on the lower traveling body, a working machine arm portion provided in an end portion of the vehicle body in such a manner as to freely move in vertical, lateral and longitudinal directions, and a working machine provided in a front end portion of the working machine arm portion, wherein said excavator comprising:

at least a pair of electrodes for electrical crushing provided on a front face of the working machine;
 a pulse generator for applying a high-voltage pulse between the electrodes;

a solution filling up a space around the electrodes;
 a case retaining the solution around the electrodes between the front face of the working machine and a subject to be excavated and provided around the electrodes;

a solution feeding pipe for feeding the solution to a peripheral portion of the electrodes;
 a pump for supplying the solution to the front face of the augering machine through the solution feeding pipe; and

a storage tank for storing the solution and being sucked up the solution by the pump, wherein the high-voltage pulse is discharged between the electrodes so as to excavate under the ground.

[0020] In accordance with the structure mentioned above, the electrical crushing can be performed by applying the high-voltage pulse between the electrodes provided on the front face of the working machine in the front end of the working machine arm portion by the pulse generator. At this time, since the solution around the electrodes is retained by the case, an electrical crushing can be efficiently performed. Further, since it is possible to direct the working machine arm portion to an

optional three dimensional direction so as to bring the surface of the electrodes of the working machine into contact with the subject to be excavated, it is possible to crush and excavate a free curved surface.

[0021] In accordance with an eighth aspect of the present invention, there is provided an excavator as cited in the seventh aspect, in which the electrodes of the working machine is structured such as to incline with respect to the vehicle body.

[0022] Accordingly, since it is possible to incline the front face (the crushing surface) of the electrodes with respect to the vehicle body, it is possible to excavate a free curved surface, so that an efficient excavating can be performed.

[0023] In accordance with a ninth aspect of the present invention, there is provided an excavator as cited in the seventh or eighth aspect, in which the case is provided with a member which is freely expanded and contracted in a longitudinal direction of the electrodes.

[0024] Accordingly, since the case is structured such as to be freely expanded and contracted in a longitudinal direction of the electrodes, an adhesion property between the surface of the subject to be excavated and the front face of the case can be improved even when a depth of excavating by the electrodes is increased. Therefore, a solution retaining property by the case can be improved, so that an efficient excavating can be performed.

[0025] In accordance with a tenth aspect of the present invention, there is provided an excavator having a working machine for excavating comprising:

at least a pair of electrodes for electrical crushing provided on a front end of the working machine for excavating;
a pulse generator for applying a high-voltage pulse between the electrodes;
a solution filling up a space around the electrodes;
a solution feeding pipe for feeding the solution to a peripheral portion of the electrodes;
a pump for supplying the solution to the front end of the working machine for excavating through the solution feeding pipe; and
soil discharging means sucking up soils crushed by a discharge in the electrodes together with the solution and discharging the soils to an outer portion of the excavated hole, wherein the high-voltage pulse is discharged between the electrodes so as to excavate the subject to be excavated.

[0026] In accordance with the structure mentioned above, the electrical crushing can be performed by applying the high-voltage pulse between the electrodes provided on the front end of the working machine for excavating by the pulse generator. Further, the excavated soils and the like are sucked with the solution by the soil discharging means so as to be discharged to an outer portion of the excavated hole. At this time, since

the solution around the electrodes can be retained by the excavated hole and the electrodes in the outer peripheral portion or the case surrounding the electrodes, an electrical crushing can be efficiently performed.

[0027] In accordance with an eleventh aspect of the present invention, there is provided an excavator as cited in the tenth aspect, in which the at least one pair of electrodes comprise an outer peripheral electrode which is similar to a shape of the hole to be excavated and an inner electrode which is arranged in a center portion of the outer peripheral electrode.

[0028] Accordingly, since the shape of the outer peripheral portion of the working machine for excavating is formed in such a manner as to be similar to the shape of the hole to be excavated, the outer peripheral portion is formed as one of at least one pair of electrodes and the other electrode is arranged in the center portion thereof, a hole having a desired shape can be excavated by the electrical crushing. Therefore, an efficient underground augering can be performed.

[0029] In accordance with a twelfth aspect of the present invention, there is provided an excavator having an upper vehicle body provided on a lower traveling body, a working machine for excavating which is brought into contact with a subject to be excavated so as to excavate, and a working machine arm which is provided with a front end portion attached to the working machine for excavating and a base end portion attached on the upper vehicle body, and operates an excavating position of the working machine for excavating by at least rotating, expanding or contracting, wherein said excavator comprising:

said working machine for excavating comprises a crushing head having an outer peripheral wall and forming a storage chamber for storing a crushed material of a subject to be excavated in an inner portion surrounded by the subject to be excavated and the outer peripheral wall when a front end portion of the outer peripheral wall is brought into contact with the subject to be excavated;
at least a pair of electrodes for electrical crushing provided within the storage chamber;
a solution filling up a space around the electrodes;
a solution feeding pipe for feeding the solution to the storage chamber; and
a pump for supplying the solution to the storage chamber through the solution feeding pipe, wherein the high-voltage pulse is discharged between the electrodes so as to excavate the subject to be excavated.

[0030] In accordance with the structure mentioned above, an electrical crushing can be performed by applying the high-voltage pulse between the electrodes provided in the crushing head of the front end portion in the working machine arm. At this time, since the storage

chamber is formed by bringing the crushing head into contact with the subject to be excavated and the solution around the electrodes is retained in a pressurized state, an electrical crushing can be efficiently performed. Further, since it is possible to crush the subject to be excavated in a state of directing the crushing head to a three dimensional optional direction, it is possible to excavate a free curved surface and a tunnel having a free cross sectional shape.

[0031] In accordance with a thirteenth aspect of the present invention, there is provided an excavator as cited in the twelfth aspect, further comprising at least one stock chamber arranged in a lower portion of the storage chamber in such a manner as to communicate therewith in series and successively storing the crushed material stored within the storage chamber, at least one movable partition plate for partitioning the stock chamber from the storage chamber or the stock chamber in an above portion, and a movable discharge plate for discharging the crushed material provided in the stock chamber at the lowermost end within the stock chambers.

[0032] Accordingly, at least one stock chamber respectively partitioned by a plurality of movable partition plates is provided in the lower portion of the storage chamber in such a manner as to communicate therewith in series, and the movable discharge plate is provided in the lowermost stock chamber among the stock chambers. Therefore, it is possible to discharge the crushed material in the lowermost stock chamber by opening the movable discharge plate after partitioning the storage chamber by each of the movable partition plates. That is, since it is possible to store the crushed material in the stock chamber every predetermined amounts so as to discharge, an amount of the solution discharged at the same time of discharging the crushed material is reduced, so that an economical excavating operation can be performed. At this time, if the structure is made such that the crushed materials are fed to the lower stock chamber when each of the stock chambers is filled with the crushed material, an amount of the solution supplied together therewith is further reduced, so that a running cost can be made very inexpensive.

[0033] In accordance with a fourteenth aspect of the present invention, there is provided an excavator as cited in the twelfth aspect, wherein a screw conveyor type discharge apparatus or a vacuum type discharge apparatus for discharging the crushed material is additionally provided in the storage chamber.

[0034] Accordingly, it is possible to continuously discharge, and an efficient excavating operation can be performed.

[0035] In accordance with a fifteenth aspect of the present invention, there is provided an excavator as cited in the twelfth aspect, further comprising a front wall for separating the inner portion of the crushing head into the storage chamber and a rear portion of the storage chamber, a solution chamber formed by a rear

portion of the front wall and temporarily storing the solution supplied from the solution feeding pipe, and a valve opening and closing a communication hole provided in the front wall in accordance that the crushing head is brought into contact with the subject to be excavated or separated from the subject to be excavated so as to feed the solution stored in the solution chamber to the storage chamber or stop the feeding.

[0036] Accordingly, since the solution chamber for temporarily storing the solution within the crushing head is provided and the valve for feeding the solution from the solution chamber to the storage chamber or stopping the feeding is provided between the solution chamber and the storage chamber, it is possible to supply a necessary amount of solution only when performing the electrical crushing. Therefore, it is possible to save the solution and an excavating operation with a reduced running cost can be performed.

[0037] In accordance with a sixteenth aspect of the present invention, there is provided an excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes and excavating a subject to be excavated by the discharge at a front end of a working machine arm, in which the improvement comprises steps of moving the working machine and bringing a front end portion of a crushing head having the electrodes therewithin into contact with the subject to be excavated so as to form a storage chamber surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head, supplying a solution within the storage chamber so as to fill up a periphery of the electrodes, applying and discharging a high-voltage pulse to the electrodes so as to crush the subject to be excavated, and discharging the crushed material stored within the storage chamber after being crushed to an outer portion of the storage chamber.

[0038] In accordance with the structure mentioned above, since the front end portion of the crushing head is brought into contact with the subject to be excavated so as to form the storage chamber and the solution is filled up around the electrodes within the storage chamber, the solution becomes in a pressurized state. Therefore, since the solution is uniformly filled up around the electrodes, a crushing can be efficiently performed.

[0039] In accordance with a seventeenth aspect of the present invention, there is provided an excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes and excavating a subject to be excavated by the discharge at a front end of a working machine arm, in which the improvement comprises steps of moving the working machine and bringing a front end portion of a crushing head having the electrodes therewithin into contact with the subject to be excavated so as to form a storage chamber surrounded by an outer peripheral

wall of the crushing head and the subject to be excavated within the crushing head, closing at least one movable partition plate and partitioning the storage chamber so as to form at least one storage chamber, supplying a solution within the storage chamber so as to fill up a periphery of the electrodes, applying and discharging a high-voltage pulse to the electrodes so as to crush the subject to be excavated, opening a movable partition plate between the storage chamber and next stock chamber so as to feed the crushed material to the stock chamber, closing the movable partition plate when the stock chamber is filled with the crushed material so as to feed the crushed material from the stock chamber to next stock chamber, successively feeding the crushed material to next stock chamber so as to feed the crushed material to the lowermost stock chamber provided with a movable discharge plate, and opening the movable discharge plate so as to discharge the crushed material to an outer portion.

[0040] In accordance with the structure mentioned above, since the solution can be filled up in the storage chamber in a state of closing the movable discharge plate and the movable partition plate, the solution is not excessively supplied, so that an amount of the supplied solution can be reduced. Further, since the movable partition plate is closed and the movable discharge plate is opened after crushing, thereby discharging the crushed material, an amount of the solution discharged together with the crushed material is reduced, so that an excavating operation with an inexpensive running cost can be performed. At this time, if the structure is made such that the crushed material is fed to the lower stock chamber when each of the stock chambers is filled with the crushed material, an amount of the solution fed together therewith can be further reduced, so that a running cost can be made very inexpensive.

[0041] In accordance with an eighteenth aspect of the present invention, there is provided an excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes and excavating a subject to be excavated by the discharge at a front end of a working machine arm, in which the improvement comprises steps of moving the working machine and bringing a front end portion of a crushing head having the electrodes therewithin into contact with the subject to be excavated so as to form a storage chamber surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head, supplying a solution within the storage chamber so as to fill up a periphery of the electrodes, applying and discharging a high-voltage pulse to the electrodes so as to crush the subject to be excavated, and continuously discharging the crushed material stored within the storage chamber after being crushed to an outer portion of the storage chamber.

[0042] In accordance with the structure mentioned above, since the crushed material stored within the stor-

age chamber can be continuously discharged to an outer portion of the storage chamber, an efficient excavating operation by an electrical crushing can be performed.

[0043] In accordance with a nineteenth aspect of the present invention, there is provided an excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes and excavating a subject to be excavated by the discharge at a front end of a working machine arm, in which the improvement comprises steps of supplying a solution to a solution chamber provided at the rear portion within a crushing head, moving the working machine and bringing a front end portion of a crushing head having the electrodes therewithin into contact with the subject to be excavated so as to form a storage chamber surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head, opening a valve and supplying the solution within the solution chamber into the storage chamber so as to fill up a periphery of the electrodes, applying and discharging a high-voltage pulse to the electrodes so as to crush the subject to be excavated, and closing the valve and discharging the crushed material stored within the storage chamber after being crushed to an outer portion of the storage chamber.

[0044] In accordance with the structure mentioned above, since the valve for the solution is opened at a time of crushing so as to supply the solution and the valve for the solution is closed when discharging the crushed material, an amount of the solution discharged together with the crushed material is reduced, so that a running cost can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

Fig. 1 is a side elevational cross sectional view of an underground augering machine in accordance with a first embodiment of the present invention;

Fig. 2 is a side elevational cross sectional view of an underground augering machine in accordance with a second embodiment at a time of starting an excavating operation;

Fig. 3 is a side elevational cross sectional view of the underground augering machine in accordance with the second embodiment in the middle of the excavating;

Figs. 4A to 4D are schematic views showing examples of a cross sectional shape of an electrode in the underground augering machine in accordance with the second embodiment;

Fig. 5 is a side elevational cross sectional view of an underground augering machine having a non-circular cross section in accordance with a third embodiment;

Fig. 6 is a front elevational view of a semicircular excavating head of the underground augering machine in accordance with the third embodiment;

Fig. 7 is a perspective view of Fig. 6;

Figs. 8A to 8B are detailed views of a shape and a mounting structure of an electrode shown in Fig. 6;

Fig. 9 is a front elevational view of a rectangular excavating head of the underground augering machine in accordance with the third embodiment;

Fig. 10 is a perspective view of Fig. 9;

Figs. 11A to 11B are detailed views of a shape and a mounting structure of an electrode shown in Fig. 9;

Figs. 12 and 13 are perspective views of an excavator in accordance with a fourth embodiment;

Fig. 14 is a detailed view of a mounting structure of an electrode shown in Fig. 13;

Fig. 15 is a side elevational cross sectional view showing details of the electrode;

Fig. 16 is a schematic view showing details of a side elevational cross sectional view of an electrode in accordance with another embodiment of Fig. 13;

Figs. 17 to 18 are perspective views of an excavator in accordance with a fifth embodiment;

Fig. 19 is a schematic view showing details of a side elevational cross sectional view of a working machine shown in Fig. 18;

Fig. 20 is a side elevational view of a boring machine in accordance with a sixth embodiment;

Fig. 21 is a side elevational view of an excavator for excavating a free cross section in accordance with a seventh embodiment;

Fig. 22 is a back elevational view of Fig. 21;

Fig. 23 is a schematic view showing details of a side elevational cross sectional view of an excavating state of the excavating head shown in Fig. 21;

Fig. 24 is a side elevational cross sectional view showing a discharge state in Fig. 23;

Fig. 25 is a schematic view showing details of a side elevational cross sectional view of an excavating state of a crushing head in accordance with an eighth embodiment;

Fig. 26 is a side elevational cross sectional view showing a discharge state in Fig. 25;

Fig. 27 is a side elevational cross sectional view showing another structure of the crushing head in accordance with the eighth embodiment;

Fig. 28 is a side elevational cross sectional view of a crushing head in accordance with a ninth embodiment;

Fig. 29 is a side elevational cross sectional view of a crushing head in accordance with a tenth embodiment;

Fig. 30 is a side elevational cross sectional view of a crushing head in accordance with an eleventh embodiment;

Fig. 31 is a detailed view of a peripheral portion of an electrode shown in Fig. 30;

Fig. 32 is a side elevational cross sectional view of a crushing head in accordance with a twelfth embodiment;

Fig. 33 is a detailed view of a valve chamber shown in Fig. 32;

Fig. 34 is a side elevational cross sectional view of a crushing head in accordance with a thirteenth embodiment;

Fig. 35 is a detailed view in the periphery of a valve system shown in Fig. 34; and

Fig. 36 is a schematic view explaining an operation and an effect of an electrical crushing by retaining a solution in accordance with the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0046] In a first embodiment in accordance with the present invention, an electric crushing is applied to an underground augering machine.

[0047] Fig. 1 shows a side elevational sectional view of an underground augering machine 20. Electrodes 1 are provided on a front face of a front end portion in the underground augering machine 20, and comprise at least one pair of positive electrode 2 and a negative electrode 3. The positive electrode 2 and the negative electrode 3 are provided apart from each other at a predetermined distance. The front end portion of the underground augering machine 20 is structured such as to freely rotate through a bearing 23 with respect to a main body portion, and each of the electrodes 1 is connected to a power cable 11 disposed in the main body portion through a slip ring 16. Then, a high-voltage pulse is applied from a pulse generator (not shown) through the power cable 11. Further, the front end portion of the underground augering machine 20 is structured such as to be swung by a swinging jack 24, so that an augering direction can be optionally set.

[0048] A solution retaining cover 14 is provided in an outer peripheral portion in a side of the main body of the underground augering machine 20, and the solution retaining cover 14 is mounted to an excavation starting end surface on the ground (for example, a side surface of a vertical hole). Further, a seal member 15 is mounted to a contact portion between the solution retaining cover 14 and the outer peripheral surface of the main body. A solution feeding hole 14a is provided in the solution retaining cover 14, and a solution 9 is supplied from the pump 6 through the solution feeding hole 14a. The solution 9 flows in a direction of an arrow A in the drawing through the main body portion of the underground augering machine and a passage between the outer peripheral surface in the front end portion and an excavated hole so as to fill up a periphery of the electrodes 1 on the front face of the front end portion. Further, a scraper 25 is arranged on the front face of the front end portion, and the solution 9 and electrically crushed soils and the like are taken into the main body from the scraper 25. Then, it is structured such that the

taken solution 9 and soils and the like flow in a direction of an arrow B in the drawing by a mixing blade 21 provided on an outer peripheral surface of a rotating shaft for rotating the front end portion of the underground augering machine, and are discharged to a rear portion of the underground augering machine through an inner portion of the main body.

[0049] In accordance with the structure mentioned above, a high-voltage pulse is applied between the positive electrode 2 and the negative electrode 3 of the electrodes 1 when the front end portion of the underground augering machine 20 is at an optional rotational angular position so that a discharge is generated, as a result, a rock and the like are crushed by a discharge energy. Since the front end portion successively rotates, a circular hole is excavated in a horizontal direction. The periphery of the electrodes 1 is filled with the solution 9 supplied from the pump 6, and a discharge energy is efficiently charged within the rock by this solution 9. At this time, since the solution 9 is prevented from leaking by means of the solution retaining cover 14 and the seal member 15, the solution 9 can be retained between the outer peripheral surface of the underground augering machine and the excavated hole. Then, the excavated soils are discharged to a rear portion of the underground augering machine together with the solution 9. As mentioned above, the underground augering machine moves forward with excavating a horizontal hole D under the ground.

[0050] Next, a second embodiment will be described below with reference to Figs. 2 to 4D.

[0051] The present embodiment shows another embodiment of the underground augering machine 20. Figs. 2 and 3 are side elevational cross sectional views of an underground augering machine 20A, and respectively show a state when an excavating is started and a state when an excavating is on the way. In accordance with the present embodiment, an outer peripheral member in the front end portion of the underground augering machine 20A is constituted by any one of the positive electrode 2 and the negative electrode 3 of the electrodes 1, and the other pole is arranged in the center portion of the front end portion. In this case, in Figs. 2 and 3, an embodiment in which the negative electrode 3 is set to the outer peripheral member is shown. An insulating body 13 is provided between the positive electrode 2 and the negative electrode 3, and a pulse generator 10 is connected to the positive electrode 2 and the negative electrode 3 through a power cable 11. A solution feeding pipe 7 for supplying the solution 9 to the periphery of the electrode 1 and a discharge pipe 8 for discharging soils excavated around the electrodes 1 to a rear portion of the underground augering machine together with the solution 9 are provided in the insulating body 13. A pump 6 is connected to the solution feeding pipe 7, and the pump 6 sucks up the solution stored in the storage tank 5 and supplies at a predetermined pressure. The outer peripheral member in a side of a

main body of the underground augering machine 20A is insulated from the negative electrode 3 with an insulating body 12, and the outer peripheral member is propelled in a excavating direction by a propelling jack 22. A solution retaining cover 14 is provided in an outer peripheral portion of the main body in the underground augering machine, and the solution retaining cover 14 is mounted on an excavation starting end surface of the ground. Then, a seal member 15 is mounted to a contact portion between the solution retaining cover 14 and the outer peripheral surface of the main body.

[0052] Figs. 4A to 4D show an example of a cross sectional shape of the positive electrode 2 and the negative electrode 3 constituting the electrodes 1 in accordance with the present embodiment. The outer peripheral member in the front end portion of the underground augering machine 20A is set as the negative electrode 3 and the positive electrode 2 is arranged in the center portion of the negative electrode 3. A discharge energy in the electrodes 1 crushes the rock and the like between the positive electrode 2 and the negative electrode 3 by applying a high-voltage pulse between the positive electrode 2 and the negative electrode 3 by the pulse generator 10. Accordingly, the shape of the electrically crushed hole can be used as it is without additionally excavating by forming the outer peripheral shape of the electrodes 1 similar to a desired cross sectional shape of the hole to be excavated. Therefore, since it is possible to easily excavate the hole having a desired shape, an excavating is efficiently performed.

[0053] Then, the solution 9 is fed at a predetermined pressure by the pump 6 so as to fill up the periphery of the electrodes 1 on the front face of the underground augering machine 20A. The solution 9 is retained by the solution retaining cover 14 and the seal member 15 so that the fed solution 9 does not flow out from the excavation starting end surface through the outer peripheral surface of the underground augering machine 20A. As a result, since the discharge energy in the electrodes 1 is surely applied to the rock through the solution 9, an efficient crushing can be performed. In this case, the structure may be made such that a solution retaining case for surrounding the periphery of the electrodes 1 is provided on the front face of the underground augering machine 20A so as to retain the solution 9 around the electrodes 1.

[0054] Next, a third embodiment will be described below with reference to Figs. 5 to 11.

[0055] When applying the electrical crushing technique in accordance with the present invention, it is unnecessary to rotate the excavating head in the case of excavating the tunnel, accordingly, it is possible to excavate all the cross section of the tunnel having a noncircular cross section. The present embodiment shows an embodiment of an underground augering machine having a noncircular cross section to which an electrical crushing is applied.

[0056] Fig. 5 shows a side elevational cross sectional

view of an underground augering machine 60 having a noncircular cross section. The electrodes 1 is mounted on a front face of an excavating head 61 provided in a front end portion of the underground augering machine 60 having a noncircular cross section, and is connected to a pulse generator 10 arranged within a tunnel by a cable or the like (not shown), thereby being applied a high-voltage pulse.

[0057] A seal member 15 is provided in the periphery of the excavating head 61, and the seal member 15 retains the solution between an inner surface of the tunnel and an outer surface of the excavating head 61. The solution 9 is fed to the excavating head 61 through the solution feeding pipe 7 by the pump 6 and is supplied to a space between an excavated surface of the tunnel in front of the seal member 15 and the outer surface of the excavating head 61 so as to be filled in the periphery of the electrodes 1.

[0058] A propelling jack 22 is attached to a rear end portion of the excavating head 61 in such a manner as to freely expand and contract, and the excavating head 61 is propelled forward in accordance that the rock and the like on the front face is crushed by an expansion and contraction of the propelling jack 22. Then, the crushed material enters within a chamber 62 provided in an inner portion of the excavating head 61, and next, is discharged to a rear portion of the tunnel by a conveyor 33 arranged at the back of the chamber 62.

[0059] In the case of performing a tunnel excavating operation by the structure mentioned above, the front end portion of the electrodes 1 in the underground augering machine 60 having a noncircular cross section is brought into contact with the rock bed and the solution 9 is filled up in the periphery of the electrodes 1. At this time, the solution 9 is retained in the front portion of the excavating head 61 by the seal member 15. Next, the electrodes 1 is discharged by applying a high-voltage pulse between the electrodes 1 from the pulse generator 10, so that the rock bed is electrically crushed. The crushed material is discharged by the conveyor 33 after entering to the chamber 62. Thereafter, the excavating head 61 moves forward by the propelling jack. In accordance with the manner mentioned above, an excavating is continuously and efficiently advanced.

[0060] Fig. 6 is a front elevational view of an excavating head 61A showing an embodiment of the excavating head having a noncircular cross section in accordance with the present embodiment, and Fig. 7 is a perspective view of the excavating head 61A. A cross section perpendicular to the excavating direction of the excavating head 61A is formed as a noncircular shape (here, a semicircular shape), and a front face portion of the cross section is separated into a plurality of fan-shaped sections 63A.

[0061] Fig. 8A is a perspective view of details of the fan-shaped sections 63A, and Fig. 8B is a cross sectional view along a line E-E in Fig. 8A. A positive electrode 2 is provided in a center portion of the fan-shaped

section 63A, a negative electrode 3 is provided in an outer peripheral wall of the fan-shaped section 63A, and the electrodes 1 are constituted by the positive electrode 2 and the negative electrode 3. The positive electrode 2 is supported by a supporting member 64A made of an insulating material, for example, a plastic or the like in a state of being insulated from the negative electrode 3. Further, since the space surrounded between the positive electrode 2 and the negative electrode 3 is filled up with the solution 9, a discharge energy is efficiently applied to the rock bed.

[0062] In accordance with the manner mentioned above, it is possible to excavate all the cross section of the tunnel having a semicircular cross section by using the excavating head 61A and it is possible to excavate a tunnel having a desired cross sectional shape by one augering, so that an operation can be efficiently performed.

[0063] Fig. 9 is a front elevational view of an excavating head 61B having a rectangular cross section in accordance with another example of the noncircular cross section, and Fig. 10 is a perspective view of the excavating head 61B. A front face portion of the excavating head 61B is separated into a plurality of rectangular sections 63B.

[0064] Fig. 11A is a perspective view of details of the rectangular sections 63B, and Fig. 11B is a cross sectional view along a line F-F in Fig. 11A. A star-shaped positive electrode 2 is provided in a center portion of the rectangular section 63B, the negative electrode 3 is provided in an outer peripheral wall of the rectangular section 63B, and the electrodes 1 are constituted by the positive electrode 2 and the negative electrode 3. The positive electrode 2 is supported by a supporting member 64B made of an insulating material, for example, a plastic or the like in a state of being insulated from the negative electrode 3. Then, since the space surrounded between the positive electrode 2 and the negative electrode 3 is filled up by the solution 9, a discharge energy can be efficiently applied to the rock bed.

[0065] In accordance with the manner mentioned above, it is possible to excavate all the cross section of the tunnel having a rectangular cross section by using the excavating head 61B, and it is possible to excavate a tunnel having a desired cross sectional shape by one augering, so that an operation can be efficiently performed.

[0066] Next, a fourth embodiment will be described below with reference to Figs. 12 to 16. The present embodiment shows an embodiment in which an electrical crushing is applied to an excavator.

[0067] Figs. 12 and 13 are perspective views of an excavator showing the present embodiment. An excavator 30 is provided with a freely traveling lower traveling body 31, and an upper rotating body 32 is provided substantially in a center portion on the lower traveling body 31 so as to freely rotate. A swinging member 37 is attached to a front portion of the upper rotating body 32

so as to freely rotate in a vertical direction, and the swinging member 37 is swung by a swing motion driving cylinder 38. A working machine 34 for an electrical crushing is attached to a front end portion of the swinging member 37 through a working machine driving cylinder 39, and it is structured such that a direction of the working machine 34 for an electrical crushing can be directed to an optional direction in a three dimensional space by an operation of the working machine driving cylinder 39. That is, it is structured such that the front face of the working machine 34 for an electrical crushing can be inclined an optional three dimensional direction with respect to the upper rotating body 32. Further, a conveyor 33 is arranged from a lower portion of the working machine 34 for an electrical crushing to a rear portion of the excavator, thereby discharging the excavated soils and the like.

[0068] A plurality of electrodes 1 are provided in the working machine 34 for an electrical crushing so as to be arranged in a two dimensional manner (in a plane manner). Each of the electrodes 1 is constituted by a positive electrode 2 and a negative electrode 3, and in the present embodiment, it is structured such that the negative electrode 3 is formed in a rectangular square pillar and a hollow shape and the positive electrode 2 is provided in a center of the hollow portion in the negative electrode 3. Then, an excavating surface of each of the electrodes 1 is arranged in such a manner as to face in the same direction, and all the excavating surfaces of a plurality of electrodes 1 constitute an excavating surface of the working machine 34 for an electrical crushing.

[0069] Fig. 14 shows a mounting structure of the electrodes 1 in the working machine 34 for an electrical crushing. The electrodes 1 is mounted to a supporting member 36 provided in the working machine 34 for an electrical crushing through a spring 35. Then, each of the electrodes 1 can move forward or rearward in a direction perpendicular to an excavating surface of the working machine 34 for an electrical crushing. Accordingly, it is structured such that each of the electrodes 1 can be closely adhered to an uneven surface on a surface of a subject to be excavated.

[0070] Further, the negative electrode 3 in each of the electrodes 1 has the same function as that of the case for retaining the solution 9, so that the solution supplied to the electrodes 1 is retained within the negative electrode 3 and around the positive electrode 2.

[0071] Fig. 15 shows an example of a side elevational cross sectional view of the electrodes 1. An insulating body 13 is provided within the hollow portion of the negative electrode 3, and the positive electrode 2 is arranged within the insulating body 13 and in the center of the hollow portion of the negative electrode 3. Further, a pulse generator 10 is connected to the positive electrode 2 and the negative electrode 3. The front end portion of the positive electrode 2 and the negative electrode 3 project forward from the front face end of the insulating body 13. A solution feeding pipe 7 is provided

in the insulating body 13, and the solution 9 in the storage tank 5 is fed in a C direction shown in the drawing by the pump 6 and is supplied to the front portion of the insulating body 13, that is, the front end portion of the positive electrode 2 and the negative electrode 3 through the solution feeding pipe 7. The supplied solution 9 is retained in an area surrounded by the negative electrode 3, the insulating body 13 and the surface of the subject to be excavated. At this time, when supplying a predetermined solution having a high viscosity, for example, a solution constituted by a grease, a water absorptive polymer and the like as the solution 9, the solution retaining area is under a pressurized state, so that the solution 9 can be easily retained around the positive electrode 2 and the negative electrode 3. Further, it is possible to fill up the periphery of the electrodes 1 within the solution retaining area with a solution retaining material 18, for example, a sponge and the like, so that the solution 9 is absorbed by the solution retaining material 18 so as to be retained. Here, in the case that a seal member 17 is provided on an outer peripheral surface of the front end portion in the negative electrode 3, the solution retaining property can be further improved.

[0072] Fig. 16 shows a structure of each of the electrodes 1 in accordance with the other embodiment, in which the positive electrode 2 and the negative electrode 3 are received within a case 19. As shown in the drawing, the case 19 for retaining the solution 9 is provided in the outer portion of the electrodes 1 at each of the electrodes 1.

[0073] As mentioned above, the solution 9 around the electrodes 1 is under a pressurized state by feeding the solution 9 having a high viscosity by means of the pump 6, so that a solution retaining property is good. Further, a solution retaining property can be improved by filling up the solution retaining area around the electrodes 1 with the solution retaining material 18.

[0074] In this case, the excavator shown in the present embodiment can be applied to, for example, a pulling down operation of the building, a crushing operation of the rock and the like due to a dynamite and the like. Further, it can be used as an excavator in an open caisson method.

[0075] Next, a fifth embodiment will be described below with reference to Figs. 17 to 19.

[0076] Figs. 17 and 18 are perspective views of an excavator showing the present embodiment. An excavator 40 is provided with a freely traveling lower traveling body 41, and an upper rotating body 42 is provided substantially in a center portion on the lower traveling body 41 so as to freely rotate. A boom 43 is attached to a front portion of the upper rotating body 42 so as to freely rotate in a vertical direction, and an arm 44 is attached to a front end portion of the boom 43. The boom 43 and the arm 44 are respectively swung by, for example, a swing motion driving cylinder. A working machine 45 for an electrical crushing having an elongate shape in a lat-

eral direction is attached to a front end portion of the arm 44 toward the front portion of the excavator 40. An angle formed between a longitudinal direction of the working machine 45 for an electrical crushing and the arm 44 can be changed by a cylinder for driving the working machine.

[0077] A plurality of electrodes 1 are provided in a front portion of the working machine 45 for an electrical crushing in a line in a longitudinal direction. Each of the electrodes 1 is constituted by a positive electrode 2 and a negative electrode 3, projects toward the front portion of the working machine for an electrical crushing in an elongate manner, and in the present embodiment, the positive electrode 2 and the negative electrode 3 are alternately arranged. Then, a periphery of all the electrodes 1 is surrounded by a seal member 46 freely expanding and contracting in a longitudinal direction of the electrodes 1. Fig. 19 shows a side elevational cross sectional view of the working machine 45 for an electrical crushing. The solution 9 supplied to the periphery of the positive electrode 2 and the negative electrode 3 is retained within the area surrounded by the seal member 46 and the surface of the subject to be excavated.

[0078] In accordance with the structure mentioned above, since the expandable seal member 46 is provided in the front portion of the working machine 45 for an electrical crushing, it is possible to retain the solution 9 around the electrodes 1 between the surface of the subject to be excavated and the seal member 46. At this time, an adhesion property between the seal member 46 and the surface of the subject to be excavated is improved by an expanding and contracting function of the seal member 46 even when the subject to be excavated is crushed due to a discharge in the electrodes 1 and an excavated depth becomes deep. As a result, a solution retaining property can be improved and an efficient excavation can be performed.

[0079] Further, since the electrodes 1 of the working machine 45 for an electrical crushing are arranged in a line, they are suitable for excavating in a narrow groove shape. Then, it is possible to cut a groove having an optional shape in a free space by optionally changing an angle between a longitudinal direction of the working machine 45 for an electrical crushing and the arm 44.

[0080] Next, a sixth embodiment will be described below with reference to Fig. 20.

[0081] The present embodiment shows an embodiment in which an electrical crushing is applied to a boring machine, and Fig. 20 is a side elevational view showing the present embodiment. A boring machine 50 is provided with a freely traveling lower traveling body 51, and an upper rotating body 52 is provided substantially in a center portion of the lower traveling body 51 so as to freely rotate. A pump 6 for supplying the solution 9 and a pulse generator 10 for generating a high-voltage pulse are arranged on the upper rotating body 52. Further, a drum 57 is provided on the upper rotating body 52, and a solution feeding pipe 7 for feeding the solution

9 from the pump 6 and a cable 55 introducing a power cable 11 connected to the pulse generator 10 to the boring machine 54 are structured such as to be freely expanded and contracted. A boom 53 is provided in the front end portion of the upper rotating body 52 so as to freely swing in a vertical direction, and a roller 58 is rotatably attached to the boom 53. Then, the cable 55 is introduced to the boring machine 54 from the drum 57 through the roller 58. Further, the excavated soils and the like are recovered to a side of the drum 57 together with the solution 9 by the cable 55 and discharged from the drum 57, and the discharged soils are discharged to an outer portion of the boring machine 50 by a conveyor 59.

[0082] An electrode for an electrical crushing is provided in the boring machine 54. The electrode 1 may be constituted by a plurality of electrodes in the same manner as that of each of the embodiments mentioned above. Otherwise, the electrode 1 may be constituted by a negative electrode 3 constituting an outer peripheral portion of the boring machine 54 and a positive electrode 2 provided in a center portion of the negative electrode 3. A case is provided in the periphery of the electrode 1, and the solution 9 fed through the cable 55 is retained around the electrode by the case.

[0083] Further, in the case that the negative electrode 3 constitutes the outer peripheral portion of the boring machine 54, the negative electrode 3 has the same function as that of the case mentioned above, so that the solution 9 can be retained within the negative electrode 3. In this case, an outer peripheral shape of the negative, electrode 3 can be formed so as to have a cross sectional shape similar to that of a boring hole to be excavated. Accordingly, since it is unnecessary to additionally excavate the boring hole after being excavated, an efficient excavation can be performed.

[0084] Next, a seventh embodiment will be described below with reference to Figs. 21 to 24.

[0085] The present embodiment shows an embodiment in which an electrical crushing is applied to a free cross section excavator, Fig. 21 is a side elevational view showing the present embodiment and Fig. 22 is a back elevational view.

[0086] A free cross section excavator 70 is provided with a freely traveling lower traveling body 71, and an upper vehicle body 72 is arranged in an upper portion of the lower traveling body 71. In the present embodiment, the upper vehicle body 72 is mounted substantially in a center portion of the lower traveling body 71 so as to freely rotate, accordingly, the upper vehicle body 72 is hereinafter referred to as an upper rotating body 72. A first arm 74 is mounted to a pedestal 73 provided in the front end portion of the upper rotating body 72 in such a manner as to freely rotate around a horizontal axis X-X and freely rotate within a plane including the horizontal axis X-X, and a second arm 75 is mounted to the front end portion of the first arm 74 in such a manner as to freely rotate within the plane including the same hori-

zontal axis X-X as that of the first arm 74. Further, a crushing head 76 is mounted to the front end portion of the second arm 75 in such a manner as to freely rotate within the plane including the same horizontal axis X-X as that of the first arm 74.

[0087] A position and a posture of the crushing head 76 are set at a predetermined excavating position by performing a rotation of the upper rotating body 72, a rotation of the first arm 74 around the horizontal axis X-X or a rotation within the plane including the horizontal axis X-X, a rotation of the second arm 75 or the crushing head 76 within the plane including the horizontal axis X-X and the like. Accordingly, as shown in Fig. 22, it is possible to excavate an excavated hole and a tunnel having a free cross sectional shape. In this case, a moving aspect of the working machine arm for setting the position and the posture of the crushing head 76 to a predetermined position is not limited to the above. That is, it is possible to operate the position and the posture of the crushing head 76 in a similar manner by rotating the working machine arm around a predetermined axis, bending or expanding and contracting. Further, the upper rotating body 72 is structured such as to freely rotate with respect to the lower traveling body 71, however, the structure is not limited to this, for example, the structure may be made such that the working body can be freely rotated with respect to the upper rotating body 72.

[0088] Fig. 23 is a cross sectional view showing a detailed structure of the crushing head 76. A seal member 46 is provided in the front end portion of the crushing head 76, and it is structured such that a storage chamber 77 is formed between a subject Z to be excavated, the outer peripheral wall of the crushing head 76 and the insulating body 13 within the crushing head 76 by bringing the seal member 46 into contact with the subject Z to be excavated disposed in the front portion. The positive electrode 2 and the negative electrode 3 of each pair of a plurality of electrodes are attached within the storage chamber 77 through the insulating body 13, and the positive electrode 2 and the negative electrode 3 are connected to a high-voltage output terminal of the same pulse generator 10 (not shown) as that mentioned above provided in a side of the vehicle body of the free cross section excavator 70 or an outer portion of the vehicle body. Further, a solution feeding pipe 7 for supplying the solution 9 from the pump 6 is connected to the storage chamber 77.

[0089] Next, an excavating method in accordance with the present embodiment will be described below.

(1) As shown in Fig. 23, the storage chamber 77 is formed by bringing the seal member 46 on the front face of the crushing head 76 into contact with the subject Z to be excavated.

(2) Next, the solution 9 is supplied from the pump 6 through the solution feeding pipe 7 and is filled up around the electrodes 1 within the storage chamber

77.

(3) Next, the subject Z to be excavated is electrically crushed by discharging the high-voltage pulse from the pulse generator 10 to the electrodes 1.

(4) After a predetermined amount of crushed materials are stored within the storage chamber 77, as shown in Fig. 24, the crushing head 76 is moved apart from the subject Z to be excavated by performing a rotation of the upper rotating body 72, the rotation of the first arm 74, or the rotation of the second arm 75 or the crushing head 76, thereby discharging the crushed material to an outer portion of the storage chamber 77.

(5) An excavation is performed by repeating the operations (1) to (4) mentioned above.

[0090] An embodiment of various kinds of crushing heads will be successively described below.

[0091] At first, an eighth embodiment will be described below with reference to Figs. 25 and 26.

[0092] Fig. 25 is a side elevational cross sectional view showing a structure of a crushing head 80 in accordance with the present embodiment. A seal member 46 is provided in the front end portion of the crushing head 80, and it is structured such that a storage chamber 81 is formed between a subject Z to be excavated, the outer peripheral wall of the crushing head 80, a bottom plate portion 80a of the crushing head 80 and the like by bringing the seal member 46 into contact with the subject Z to be excavated in the same manner as mentioned above. The positive electrode 2 and the negative electrode 3 of each pair of a plurality of electrodes 1 are attached to the front face of the crushing head 80 through an insulating member 82, and the positive electrode 2 and the negative electrode 3 are connected to a high-voltage output terminal of the same pulse generator 10 (not shown) as that mentioned above provided in a side of the vehicle body of the free cross section excavator 70 or an outer portion of the vehicle body. Further, a hole 83 having a predetermined size is provided in the insulating member 82 so as to allow the crushed material to pass. Still further, the solution feeding pipe 7 is attached to the upper portion of the crushing head 80, and the structure is made such that the solution 9 can be supplied from the pump (not shown) through the solution feeding pipe 7. Then, a stock chamber 84 which can partition from the above storage chamber 81 is formed in the lower portion of the storage chamber 81, and a discharge port 85 is provided in the lower portion of the stock chamber 84. A movable discharge plate 87 which is opened and closed by a first cylinder 86 is provided in the discharge port 85, and a movable partition plate 89 which is opened and closed by a second cylinder 88 is provided between the storage chamber 81 and the stock chamber 84.

[0093] Next, an excavating method in accordance with the present embodiment will be described below.

(1) As shown in Fig. 25, the storage chamber 81 is formed by bringing the seal member 46 on the front face of the crushing head 80 into contact with the subject Z to be excavated.

(2) Next, the movable discharge plate 87 and the movable partition plate 89 are closed by operating the first cylinder 86 and the second cylinder 88, thereby partitioning the storage chamber 81 and the stock chamber 84.

(3) Next, the solution 9 is supplied to the storage chamber 81 from the solution feeding pipe 7 and is filled up around the electrodes 1.

(4) Next, the subject Z to be excavated is crushed by discharging the high-voltage pulse from the pulse generator 10 to the electrodes 1.

(5) Next, as shown in Fig. 25, the crushed material stored in the storage chamber 81 is moved to the storage chamber 84 by operating the second cylinder 88 so as to open the movable partition plate 89.

(6) Further, after a predetermined amount of crushed materials are stored in the stock chamber 84, as shown in Fig. 26, the second cylinder 88 is operated so as to close the movable partition plate 89 and next the first cylinder 86 is operated so as to open the movable discharge plate 87, thereby discharging the crushed material to an outer portion of the stock chamber 84.

(7) An excavation is performed by repeating the operations (1) to (6) mentioned above.

[0094] Accordingly, since it is possible to excavate without moving the crushing head 80 apart from the subject Z to be excavated, a working efficiency is improved. Further, since at first the solution 9 is supplied only to the storage chamber 81, a supply amount of the solution 9 is a little, and since an amount of the discharged solution 9 is reduced to only an amount temporarily stored in the stock chamber 84 in the case of discharging the crushed materials, a running cost can be reduced.

[0095] In this case, in accordance with the present embodiment, one stock chamber 84 is provided in the lower portion of the storage chamber 81, however, the present invention is not limited to this. For example, as shown in Fig. 27, the structure may be made such that a plurality of stock chambers 84a and 84 are arranged in the lower portion of the storage chamber 81 in series, and movable partition plates 89a and 89 are opened and closed by respective second cylinders 88a and 88 partitioning between the stock chambers. In this case, the crushed materials stored in the storage chamber 81 are successively fed to the lower stock chambers 84a and 84, and fed to the next stock chamber 84 when the stock chamber 84a is filled. As mentioned above, after being fed to the lowermost stock chamber 84, it is possible to discharge to the outer portion by opening the movable discharge plate 87 in the lowermost stock chamber 84. Accordingly, it is possible to reduce a discharging

amount of the solution 9 and to make a running cost very inexpensive.

[0096] Next, a crushing head 80A in accordance with a ninth embodiment will be described below with reference to Fig. 28. In this case, since the structure of the present embodiment is the same as that of the eighth embodiment except a structure for discharging the crushed materials, the same reference numerals are attached to the same elements and an explanation thereof will be omitted.

[0097] A screw conveyor type discharge apparatus 90 for discharging the crushed materials is provided in the lower end portion of the crushing head 80A. The screw conveyor type discharge apparatus 90 is constituted by a discharge pipe 92, a screw 93 rotating around a rotational axis along a longitudinal direction of the discharge pipe 92 within the discharge pipe 92, and a screw driving apparatus (not shown) for rotating the screw 93.

[0098] Next, an excavating method will be described below.

(1) As shown in Fig. 28, the storage chamber 81 is formed by bringing the seal member 46 on the front face of the crushing head 80A into contact with the subject Z to be excavated.

(2) Next, the solution 9 is supplied to the storage chamber 81 from the solution feeding pipe 7 and is filled up around the electrodes 1.

(3) Next, the subject Z to be excavated is crushed by discharging the high-voltage pulse from the pulse generator 10 to the electrodes 1.

(4) Next, the crushed material is discharged to the outer portion of the storage chamber 81 by operating the screw conveyor type discharge apparatus 90.

[0099] Accordingly, an operation for excavating and discharging the crushed material can be continuously and efficiently performed.

[0100] In this case, the structure may be made such that a separating apparatus (not shown) for separating the crushed material from the solution 9 is provided in a discharge port of the screw conveyor type discharge apparatus 90, thereby reusing the solution 9 separated by the separating apparatus.

[0101] Next, a crushing head 80B in accordance with a tenth embodiment will be described below with reference to Fig. 29. In this case, since the structure of the present embodiment is the same as that of the eighth embodiment except a structure for discharging the crushed material, the same reference numerals are attached to the same elements and an explanation thereof will be omitted.

[0102] A vacuum type discharge apparatus 91 for discharging the crushed material is provided in the lower end portion of the crushing head 80B. The vacuum type discharge apparatus 91 is structured such as to set a pressure within a discharge pipe 92 to a pressure lower

than a pressure of the open air and discharge the crushed material and the solution 9 flowed into the discharge pipe 92 to the outer portion of the storage chamber 81.

[0103] Next, an excavating method will be described below.

(1) As shown in Fig. 29, the storage chamber 81 is formed by bringing the seal member 46 on the front face of the crushing head 80B into contact with the subject Z to be excavated.

(2) Next, the solution is supplied to the storage chamber 81 from the solution feeding pipe 7 so as to be filled up around the electrodes 1.

(3) Next, the subject Z to be excavated is crushed by discharging the high-voltage pulse from the pulse generator 10 to the electrodes 1.

(4) Next, the crushed material is discharged to the outer portion of the storage chamber 81 by operating the vacuum type discharge apparatus 91 by a vacuum apparatus (not shown).

[0104] Accordingly, an operation for excavating and discharging the crushed material can be continuously and efficiently performed.

[0105] In this case, the structure may be made such that a separating apparatus (not shown) for separating the crushed material from the solution 9 is provided in the discharge port of the vacuum type discharge apparatus 91, thereby reusing the separated solution 9.

[0106] Next, a crushing head 95 in accordance with an eleventh embodiment will be described below with reference to Fig. 30.

[0107] The seal member 46 is attached to the front end portion of the outer peripheral wall in the crushing head 95, and it is structured such that the storage chamber 81 is formed between the subject Z to be excavated, the outer peripheral wall of the crushing head 95 and a front wall 97 partitioning between an inner front portion and a rear portion of the crushing head 95 by bringing the seal member 46 into contact with the subject Z to be excavated. A pair of positive electrode 2 and negative electrode 3 of each of a plurality of electrodes 1 are provided within the storage chamber 81 through the front wall 97 comprising an insulating body. Further, a solution chamber 96 separated from the storage chamber 81 by the front wall 97 is provided in the inner rear portion of the crushing head 95.

[0108] Fig. 31 is a detailed view of a peripheral portion of the positive electrode 2 and the negative electrode 3 in each of the electrodes 1. A recess portion 98 depressed in a side of the storage chamber 81 is provided in the front wall 97, and a communication hole 99 for supplying the solution 9 to the storage chamber 81 from the solution chamber 96 is provided in the recess portion 98. Further, a through hole 100 passing from the solution chamber 96 to the storage chamber 81 is provided in a center of a bottom portion in the recess por-

tion 98. A front end side (a side of the storage chamber 81) of the electrodes 1 slidably passes through the through hole 100, and a base end portion of the electrode 1 is inserted into a supporting hole 102 provided in a rear wall 101 of the solution chamber 96. A flange 103 is provided in the center portion of the electrode 1, and a spring 104 is interposed between the flange 103 and the rear wall 101, thereby always urging the electrode 1 to a direction of the front wall 97. During an excavating operation, the structure is made such that the front end portion of the electrode 1 is brought into contact with the subject Z to be excavated due to the urging force. Further, a valve 105 is provided on the front face of the flange 103, and the valve 105 is brought into contact with the front wall 97 due to the urging force of the spring 104 as shown by a narrow two dot chain line in Fig. 31, thereby stopping the supply of the solution 9 from the solution chamber 96 to the storage chamber 81.

[0109] Next, an excavation will be described below.

(1) The solution 9 is supplied from the solution feeding pipe 7 to the solution chamber 96.

(2) Next, as shown in Fig. 30, the storage chamber 81 is formed by bringing the seal member 46 of the crushing head 95 into contact with the subject Z to be excavated. At this time, the electrode 1 is pressed by the subject Z to be excavated so as to move rearward against the urging force of the spring 104, so that the valve 105 is apart from the front wall 97. At this time, the solution 9 is supplied to the storage chamber 81 through the communication hole 99 as shown in an arrow and is filled up around the electrode 1.

(3) Next, the subject Z to be excavated is crushed by discharging the high-voltage pulse from the pulse generator 10 to the electrodes 1.

(4) Next, the crushing head 95 is moved so as to move the seal member 46 apart from the subject Z to be excavated, and the crushed material at this time is discharged to the outer portion of the storage chamber 81. At this time, the electrode 1 moves in a direction of the front wall 97 due to the urging force of the spring 104, so that the valve 105 is brought into contact with the front wall 97 as shown by a narrow two dot chain line in Fig. 31, thereby stopping the supply of the solution 9 to the storage chamber 81.

(5) The operations (1) to (4) mentioned above are repeated so as to perform an excavation.

[0110] As mentioned above, since the supply of the solution to the storage chamber 81 is stopped by the valve 105 at a time of moving the crushing head 95 apart from the subject Z to be excavated, an amount of the solution 9 discharged together with the crushed material is reduced, so that a running cost can be reduced.

[0111] Next, a crushing head 95A in accordance with a twelfth embodiment will be described below with reference to Fig. 32.

[0112] The seal member 46 is attached to the front end portion of the outer peripheral wall in the crushing head 95A, and it is structured such that the storage chamber 81 is formed between the subject Z to be excavated, the outer peripheral wall of the crushing head 95A and a front wall 97 partitioning between an inner front portion and a rear portion of the crushing head 95A by bringing the seal member 46 into contact with the subject Z to be excavated. Further, a solution chamber 96 separated by the front wall 97 is provided in the inner rear portion of the crushing head 95A. Then, a pair of positive electrode 2 and negative electrode 3 of a plurality of electrodes 1 are provided within the storage chamber 81 through the front wall 97 comprising an insulating body. A base end portion of each of the electrodes 1 (the positive electrode 2 and the negative electrode 3) passes to the solution chamber 96 from the storage chamber 81 and is slidably supported to the front wall 97. Further, a step portion having an end surface 114 in the side of the front wall 97 is provided in the center portion of each of the electrodes 1, and each of the electrodes 1 is urged forward by a spring interposed between the end surface 114 and the front wall 97. Due to the urging force, during the excavating operation, each of the electrodes 1 is always brought into contact with the subject Z to be excavated. Further, a valve chamber 120 is provided substantially in a center portion of the front wall 97. Further, a discharge port 111 is provided on a lower surface of the storage chamber 81, and a discharge gate 113 opened and closed by a cylinder 112 is provided.

[0113] Fig. 33 is a detailed cross sectional view of the valve chamber 120. A first communication hole 121 communicated with the solution chamber 96 and a second communication hole 122 communicated with the storage chamber 81 are provided in the valve chamber 120. Further, a valve stem 123 provided with a valve 105 in a front end (in the side of the storage chamber 81) is provided within the valve chamber 120, and a rear end portion thereof passes through the valve chamber 120 and engaged with a solenoid 124. Then, the valve stem 123 is always urged to the side of the second communication hole 122 by the spring 125, and the valve stem 123 moves to the solenoid 124 by energizing the solenoid 124 so as to open and close the second communication hole 122.

[0114] Next, an excavating method will be described below.

(1) The solution 9 is supplied to the solution chamber 96 from the solution feeding pipe 7.

(2) As shown in Fig. 32, the storage chamber 81 is formed by bringing the seal member 46 of the crushing head 95A into contact with the subject Z to be excavated. At this time, the front end portion of

the electrode 1 is brought into contact with the subject Z to be excavated so as to be pressed, and moves rearward at a predetermined distance against the urging force of the spring 110. Accordingly, the electrode 1 is always brought into contact with the subject Z to be excavated due to the urging force.

(3) The solenoid 124 is operated by energizing so as to move the valve stem 123 to the side of the solenoid 124, thereby opening the valve 105 so as to communicate the second communication hole 122. The solution 9 in the solution chamber 96 is supplied to the storage chamber 81 through the first communication hole 121 at a predetermined amount and is filled up around the electrode 1.

(4) The valve 105 is closed by stopping an energizing of the solenoid 124, thereby stopping the supply of the solution to the storage chamber 81.

(5) The subject Z to be excavated is crushed by discharging the high-voltage pulse by the pulse generator 10 to the electrode 1.

(6) After the crushed materials are stored in the storage chamber 81 at a predetermined amount, the discharge gate 113 is operated by the cylinder 112 so as to open the discharge port 111 and discharge the crushed material to the outer portion of the storage chamber 81.

(7) The discharge gate 113 is operated so as to close the discharge port 111.

(8) An excavation is performed by repeating the operations (1) to (7) mentioned above.

[0115] Accordingly, the excavating operation can be performed without moving the crushing head 95A apart from the subject Z to be excavated, so that an efficient operation can be performed. Further, a supply amount of the solution 9 can be optionally adjusted, thereby reducing the discharge amount of the solution 9 at a time of discharging the crushed material to the outer portion of the storage chamber 81 so as to reduce a running cost.

[0116] Next, a crushing head 95B in accordance with a thirteenth embodiment will be described below with reference to Fig. 34.

[0117] Since the structure in accordance with the present embodiment is different from the twelfth embodiment only in view of an opening and closing mechanism for a valve 105, the same reference numerals are attached to the same elements and an explanation thereof will be omitted.

[0118] A depressed recess portion 98 is provided in the side of the storage chamber 81 substantially in the center of the front wall 97, a communication hole 99 for communicating the solution chamber 96 with the storage chamber 81 is provided in the recess portion 98, and a valve stem 130 is slidably arranged in the center portion of the recess portion 98.

[0119] Fig. 35 is a detailed cross sectional view

around the valve stem 130. A through hole 133 passing from the solution chamber 96 to the storage chamber 81 is provided in a center of a bottom portion in the recess portion 98, and a base end side of the valve stem 130 slidably passes through the through hole 133. A flange 134 is provided in an end portion in the side of the solution chamber 96 of the valve stem 130, and a valve 105 is provided on a surface of the flange 134 facing to the side of the solution chamber 96 of the front wall 97 near the recess portion 98. Further, a flange 132 is provided in a middle portion of the valve stem 130 passing to the side of the storage chamber 81, a spring 131 is provided between the flange 132 and the bottom portion of the recess portion 98, and the valve stem 130 is urged to the side of the storage chamber 81 by the spring 131. Then, in the case that the front end of the valve stem 130 is brought into contact with the subject Z to be excavated so as to be pressed against the urging force, the valve stem 130 moves while contracting the spring 131, so that the valve 105 is opened and the solution chamber 96 and the storage chamber 81 are communicated. Further, in the case that the front end of the valve stem 130 moves apart from the subject Z to be excavated, the valve stem 130 moves to a position shown by a narrow two dot chain line due to the urging force of the spring 131, so that the valve 105 is closed.

[0120] Next, an excavating method will be described below.

(1) The solution 9 is supplied from the solution feeding pipe 7 to the solution chamber 96. At this time, the valve 105 is closed and the solution 9 is stored in the solution chamber 96.

(2) As shown in Fig. 34, the storage chamber 81 is formed by bringing the seal member 46 of the crushing head 95B into contact with the subject Z to be excavated. At this time, the front end portion of the electrode 1 (a pair of positive electrode 2 and negative electrode 3) is brought into contact with the subject Z to be excavated so as to contract the spring 110 at a predetermined amount. Simultaneously, the front end of the valve stem 130 is also brought into contact with the subject Z to be excavated so as to be pressed, thereby contracting the spring 131 and opening the valve 105. Accordingly, the solution 9 is supplied to the storage chamber 81 from the solution chamber 96 through the communication hole 99 so as to be filled up around the electrodes 1.

(3) The subject Z to be excavated is crushed by discharging the high-voltage pulse by the pulse generator 10 to the electrode 1.

(4) After the crushed materials are stored in the storage chamber 81 at a predetermined amount, the crushing head 95B is moved rearward so as to move the seal member 46 from the subject Z to be excavated and discharge the crushed material to the outer portion of the storage chamber 81. At this

time, the valve stem 130 moves forward as shown by a narrow two dot chain line in Fig. 35, and the valve 105 is closed so as to stop the supply of the solution 9 to the storage chamber 81.

(5) An excavation is performed by repeating the operations (1) to (4) mentioned above.

[0121] Accordingly, an amount of the solution 9 discharged at a time of discharging the crushed materials can be reduced, and a running cost can be reduced.

[0122] As mentioned above, in accordance with the present invention, it is structured such that the solution 9 such as an electrolyte solution and the like can be surely filled up and retained around the electrodes provided in the front end portion of the underground augering machine and within the excavating head of the excavator. As a result, it is possible to perform an efficient electrical crushing by discharging an electricity into the crushed material itself such as the rock bed and the like, or generating an impulse wave within the solution due to the discharge within the solution.

[0123] That is, an efficient crushing obtained by discharging an electricity into the crushed material itself such as the rock bed and the like can be performed by properly setting an ascending time of the pulse voltage applied to the electrodes. For example, Fig. 36 shows a normal relation between an ascending time of an applied pulse voltage and a withstand voltage in each of the insulating materials when applying the pulse voltage. Here, a horizontal axis shows an ascending time of an applied pulse voltage (normally shown by a time required for ascending the pulse voltage from 10 % of the maximum value to 90 % of the maximum value), a vertical axis shows a withstand voltage, and the horizontal axis is shown by a semi-logarithmic scale in a logarithmic scale. In the drawing, curves 141, 142 and 143 respectively show properties of a water, a marble and a sandstone. As is also understood from the drawing, in the case of using, for example, a water for the solution, the withstand voltage of the marble, the sandstone and the like are smaller than that of the water when the ascending time of the pulse voltage is short. Accordingly, at this time, the discharged current easily flows to the rock rather than the solution (water), so that it is proper for improving a crushing efficiency of the rock by excavating the hole in the rock at a time of starting the crushing, or deeply crushing the rock. Further, in the case mentioned above, when the ascending time of the pulse voltage is long, the withstand voltage of the rock such as the marble, the sandstone and the like is larger than that of the water. Accordingly, at this time, the discharged current easily flows to the solution (water) rather than the rock, so that it is proper for widely crushing by the impulse wave generated within the solution.

[0124] As mentioned above, in the case of using the same solution, it is possible to select a path of the discharged current by changing the ascending time of the applied pulse voltage in accordance with the relation

among the ascending time of the applied pulse voltage, the withstand voltage of the component such as the rock and the like as the subject to be crushed with respect to the ascending time, and the withstand voltage of the solution. Accordingly, it is possible to select whether the discharge is performed within the solution or the discharge is performed within the rock. As a result, it is possible to efficiently perform an underground augering by an electrical crushing, an excavating of the rock bed and the like.

INDUSTRIAL APPLICABILITY

[0125] Since it is possible to perform an electrical crushing in a state of surely filling up the solution such as an electrolytic solution and the like around the electrodes provided in the front end portion of the underground augering machine or within the excavating head of the excavator and efficiently retain the solution, the present invention is useful for an underground augering machine which crushes or excavates particularly a horizontal hole, an excavator and an excavating method.

Claims

1. An underground augering machine comprising:

at least a pair of electrodes (1) for electrical crushing provided on a front face of the underground augering machine;
 a pulse generator (10) for applying a high-voltage pulse between the electrodes;
 a solution (9) filling up a space around said electrodes;
 a solution retaining cover (14) provided on an outer peripheral surface of said augering machine and retaining the solution around the electrodes between the front face of the augering machine and the ground;
 a solution feeding pipe (7) for feeding said solution to a peripheral portion of said electrodes;
 a pump (6) for supplying said solution to the front face of said augering machine through the solution feeding pipe; and
 a storage tank (5) for storing said solution and being sucked up the solution by the pump, wherein the high-voltage pulse is discharged between said electrodes so as to excavate under the ground.

2. An underground augering machine comprising:

at least a pair of electrodes (1) for electrical crushing provided on a front face of the underground augering machine;
 a pulse generator (10) for applying a high-voltage pulse between the electrodes (1);
 a solution (9) filling up a space around said

electrodes;

a case (19) provided around said electrodes and retaining the solution around the electrodes between the front face of said augering machine and the ground;

a solution feeding pipe (7) for feeding the solution to a peripheral portion of said electrodes;

a pump (6) for supplying said solution to the front face of the augering machine through the solution feeding pipe; and

a storage tank (5) for storing said solution and being sucked up the solution by the pump, wherein the high-voltage pulse is discharged between said electrodes so as to excavate under the ground.

3. An underground augering machine as claimed in claim 1 or 2, wherein said at least one pair of electrodes (1) comprise an outer peripheral electrode (3) which is similar to a shape of the hole to be excavated and an inner electrode (2) which is arranged in a center portion of the outer peripheral electrode.

4. An underground augering machine as claimed in claim 1 or 2, wherein a solution retaining member (18) for retaining said solution (9) is provided in such a manner as to fill up the periphery of said electrodes (1).

5. An underground augering machine as claimed in claim 1 or 2, wherein a continuous soil discharging mechanism (33) for continuously discharging soils and the like crushed and excavated by said electrodes (1) is provided.

6. An underground augering machine as claimed in claim 2, wherein said case (19) constitutes any one of a positive electrode (2) or a negative electrode (3) of said at least one pair of electrodes (1).

7. An excavator having a lower traveling body structured such as to freely travel, a vehicle body provided on the lower traveling body, a working machine arm portion provided in an end portion of the vehicle body in such a manner as to freely move in vertical, lateral and longitudinal directions, and a working machine provided in a front end portion of the working machine arm portion, wherein said excavator comprising:

at least a pair of electrodes (1) for electrical crushing provided on a front face of said working machine;

a pulse generator (10) for applying a high-voltage pulse between the electrodes;

a solution (9) filling up a space around the electrodes;

- a case (19) retaining the solution around the electrodes between the front face of said working machine and a subject to be excavated and provided around said electrodes;
- a solution feeding pipe (7) for feeding the solution to a peripheral portion of the electrodes;
- a pump (6) for supplying the solution to the front face of said augering machine through the solution feeding pipe; and
- a storage tank (5) for storing said solution and being sucked up the solution (9) by said pump (6), wherein the high-voltage pulse is discharged between said electrodes so as to excavate under the ground.
8. An excavator as claimed in claim 7, wherein the electrodes (1) of said working machine is structured such as to incline with respect to said vehicle body.
9. An excavator as claimed in claim 7, wherein said case (19) is provided with a member (35) which is freely expanded and contracted in a longitudinal direction of the electrodes (1).
10. An excavator having a working machine for excavating comprising:
- at least a pair of electrodes (1) for electrical crushing provided on a front end of said working machine (54) for excavating;
- a pulse generator (10) for applying a high-voltage pulse between the electrodes;
- a solution (9) filling up a space around the electrodes;
- a solution feeding pipe (7) for feeding the solution to a peripheral portion of said electrodes;
- a pump (6) for supplying the solution to the front end of said working machine for excavating through the solution feeding pipe; and
- soil discharging means (55, 57) sucking up soils crushed by a discharge in said electrodes together with said solution and discharging the soils to an outer portion of the excavated hole, wherein the high-voltage pulse is discharged between said electrodes (1) so as to excavate the subject to be excavated.
11. An excavator as claimed in claim 10, wherein said at least one pair of electrodes (1) comprise an outer peripheral electrode which is similar to a shape of the hole to be excavated and an inner electrode which is arranged in a center portion of the outer peripheral electrode.
12. An excavator (70) having an upper vehicle body provided on a lower traveling body, a working machine for excavating which is brought into contact with a subject to be excavated so as to exca-

vate, and a working machine arm which is provided with an end portion attached on said upper vehicle body and the other end portion attached to the working machine for excavating, and operates an excavating position of the working machine for excavating by at least rotating, expanding or contracting, wherein said excavator comprising:

said working machine for excavating comprises a crushing head (76, 80, 80A, 80B, 95, 95A, 95B) having an outer peripheral wall and forming a storage chamber (77, 81) for storing a crushed material of a subject to be excavated in an inner portion surrounded by a surface of the subject to be excavated and the outer peripheral wall when a front end portion of the outer peripheral wall is brought into contact with the subject to be excavated;

at least a pair of electrodes (1) for electrical crushing provided within the storage chamber;

a solution (9) filling up a space around the electrodes;

a solution feeding pipe (7) for feeding the solution to the storage chamber; and

a pump (6) for supplying said solution to said storage chamber through the solution feeding pipe, wherein the high-voltage pulse is discharged between said electrodes so as to excavate the subject to be excavated.

13. An excavator as claimed in claim 12, further comprising at least one stock chamber (84, 84a) arranged in a lower portion of said storage chamber (81) in such a manner as to communicate therewith in series and successively storing said crushed material stored within the storage chamber, at least one movable partition plate (89, 89a) for partitioning the stock chamber from said storage chamber (81) or the stock chamber (84a) in an above portion, and a movable discharge plate (87) for discharging the crushed material provided in the stock chamber (84) at the lowermost end within the stock chambers.
14. An excavator as claimed in claim 12, wherein a screw conveyor type discharge apparatus (90) or a vacuum type discharge apparatus (91) for discharging said crushed material is additionally provided in said storage chamber (81).
15. An excavator as claimed in claim 12, further comprising a front wall (97) for separating the inner portion of said crushing head (95, 95A, 95B) into said storage chamber (81) and a rear portion of the storage chamber, a solution chamber (96) formed by a rear portion of the front wall and temporarily storing the solution (9) supplied from said solution feeding pipe (7), and a valve (105) opening and closing a

communication hole (99, 121, 122) provided in the front wall in accordance that said crushing head is brought into contact with the subject to be excavated so as to feed the solution stored in the solution chamber to said storage chamber or stop the feeding.

16. An excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes (1) and excavating a subject to be excavated by the discharge at a front end of a working machine arm, wherein the improvement comprises steps of:

moving said working machine and bringing a front end portion of a crushing head (76) having said electrodes (1) therewithin into contact with the subject to be excavated so as to form a storage chamber (77) surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head;
supplying a solution (9) within the storage chamber so as to fill up a periphery of said electrodes;
applying and discharging a high-voltage pulse to said electrodes so as to crush the subject to be excavated; and
discharging the crushed material stored within the storage chamber (77) after being crushed to an outer portion of the storage chamber.

17. An excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes (1) and excavating a subject to be excavated by the discharge at a front end of a working machine arm, wherein the improvement comprises steps of:

moving said working machine and bringing a front end portion of a crushing head (80) having said electrodes (1) therewithin into contact with the subject to be excavated so as to form a storage chamber (81) surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head;
closing at least one movable partition plate (89, 89a) and partitioning the storage chamber so as to form at least one storage chamber (84, 84a);
supplying a solution (9) within the storage chamber (81) so as to fill up a periphery of said electrodes;
applying and discharging a high-voltage pulse

to said electrodes so as to crush the subject to be excavated;

opening a movable partition plate (89a) between the storage chamber and next stock chamber (84a) so as to feed the crushed material to the stock chamber (84a);

closing the movable partition plate (89a) when the stock chamber (84a) is filled with the crushed material so as to feed the crushed material from the stock chamber to next stock chamber;

successively feeding the crushed material to next stock chamber so as to feed the crushed material to the lowermost stock chamber (84) provided with a movable discharge plate (87); and

opening the movable discharge plate (87) so as to discharge the crushed material to an outer portion.

18. An excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes (1) and excavating a subject to be excavated by the discharge at a front end of a working machine arm, wherein the improvement comprises steps of:

moving said working machine and bringing a front end portion of a crushing head (80) having said electrodes therewithin into contact with the subject to be excavated so as to form a storage chamber (81) surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head;
supplying a solution (9) within the storage chamber so as to fill up a periphery of said electrodes;
applying and discharging a high-voltage pulse to said electrodes so as to crush the subject to be excavated; and
continuously discharging the crushed material stored within the storage chamber (81) after being crushed to an outer portion of the storage chamber.

19. An excavating method of an excavator by an electrical crushing which is provided with a working machine generating a discharge in accordance with a high-voltage energy in electrodes (1) and excavating a subject to be excavated by the discharge at a front end of a working machine arm, wherein the improvement comprises steps of:

supplying a solution (9) to a solution chamber (96) provided at the rear portion within a crushing head (95, 95A, 95B);

moving said working machine and bringing a front end portion of a crushing head (95, 95A, 95B) having said electrodes therewithin into contact with the subject to be excavated so as to form a storage chamber (81) surrounded by an outer peripheral wall of the crushing head and the subject to be excavated within the crushing head;

opening a valve (105) and supplying the solution within said solution chamber (96) into the storage chamber so as to fill up a periphery of said electrodes;

applying and discharging a high-voltage pulse to said electrodes so as to crush the subject to be excavated; and

closing said valve and discharging the crushed material stored within the storage chamber (81) after being crushed to an outer portion of the storage chamber.

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FIG. 1

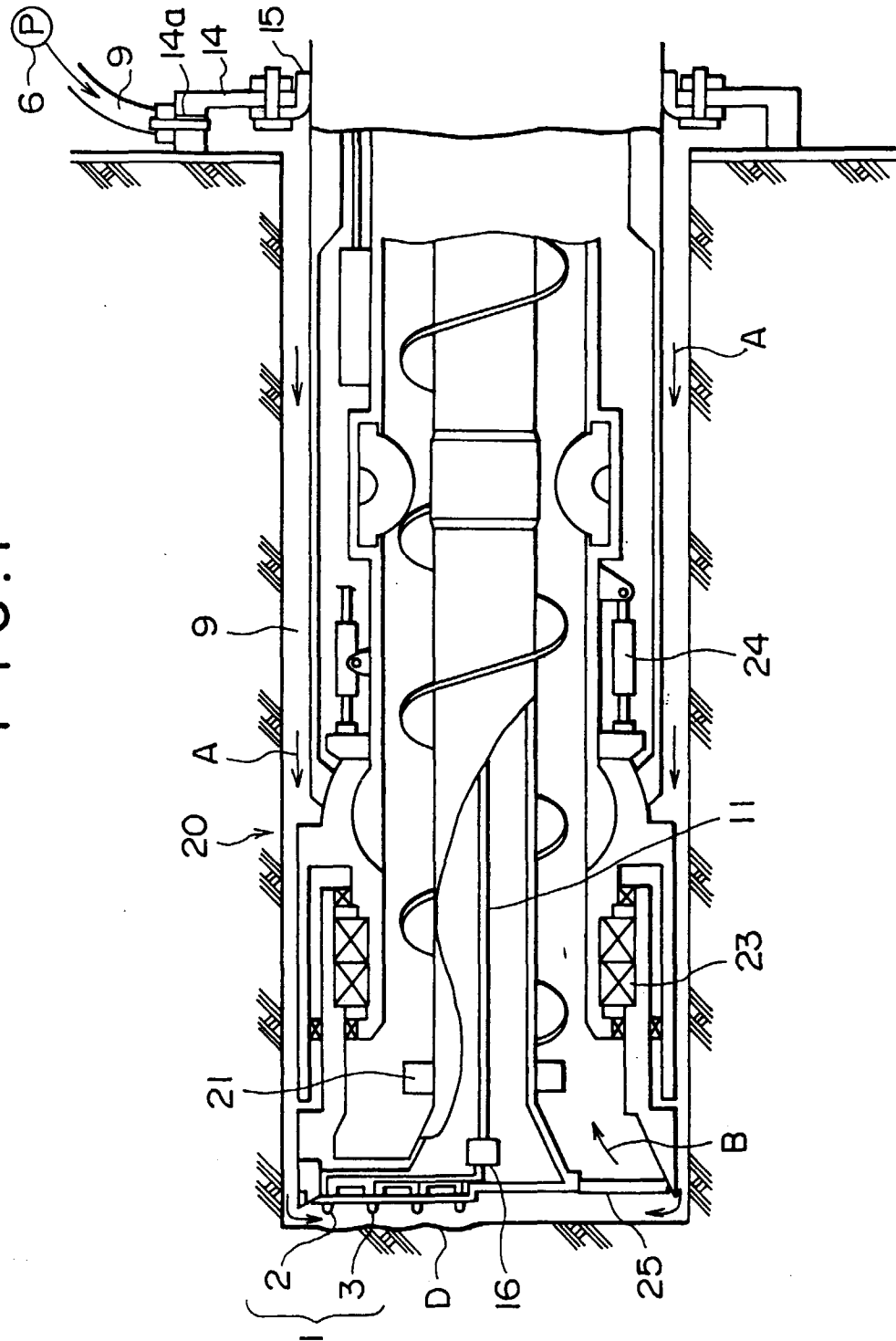


FIG. 2

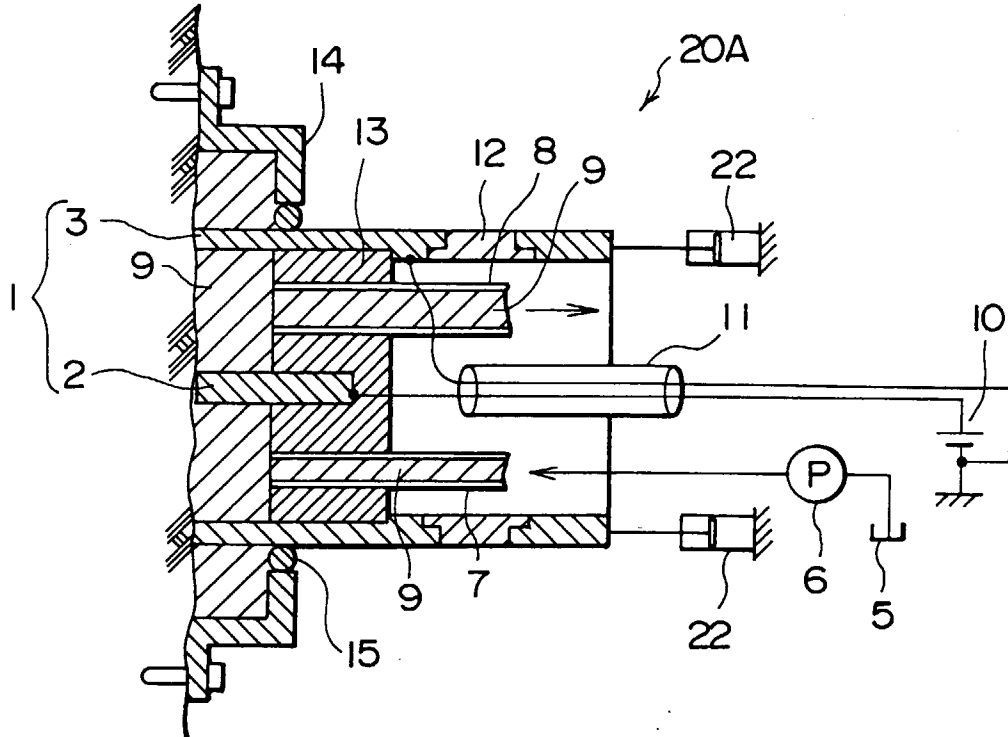


FIG. 3

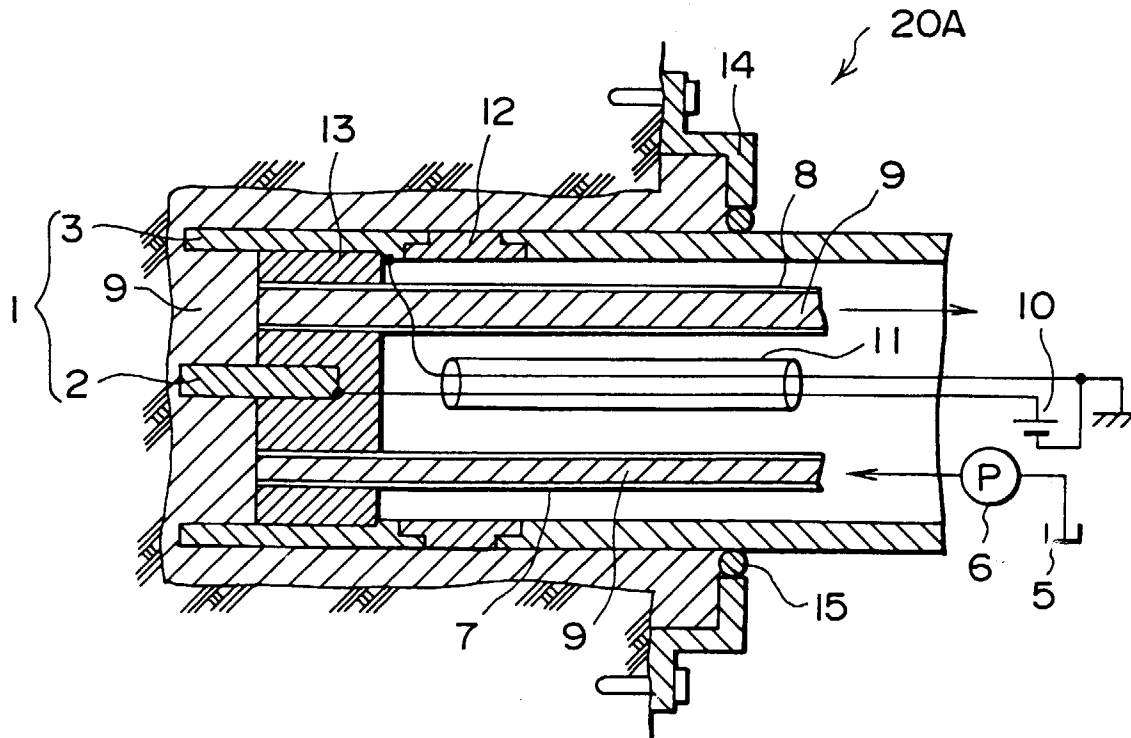


FIG. 4A

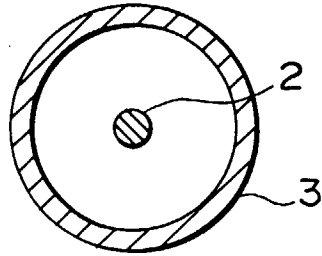


FIG. 4B

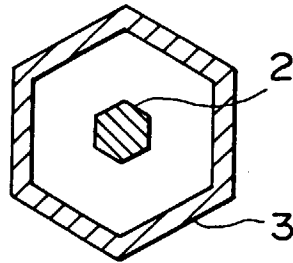


FIG. 4C

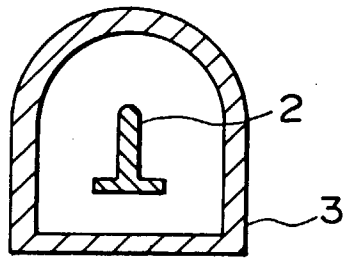


FIG. 4D

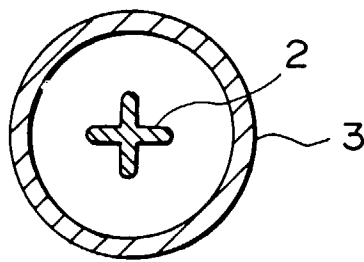


FIG. 5

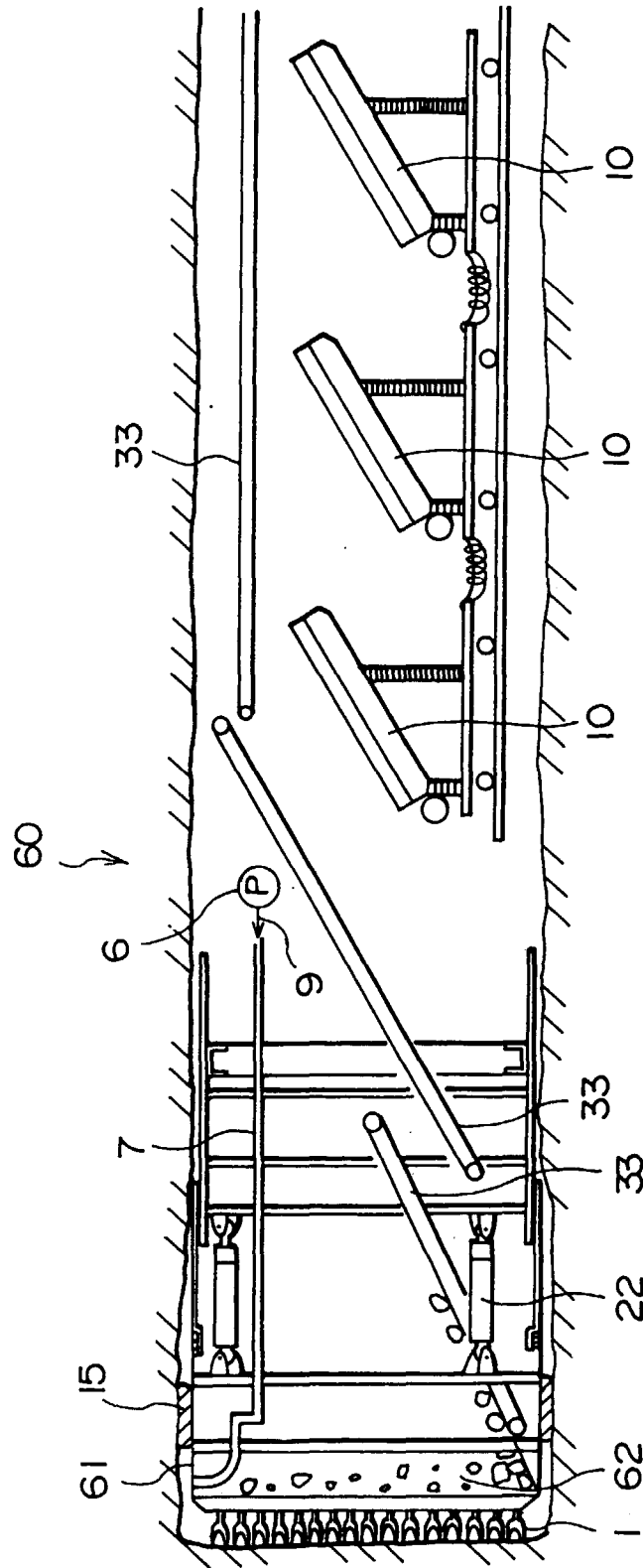


FIG. 6

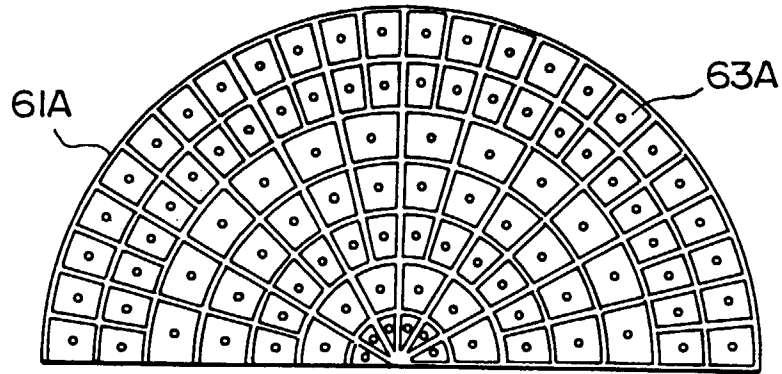


FIG. 7

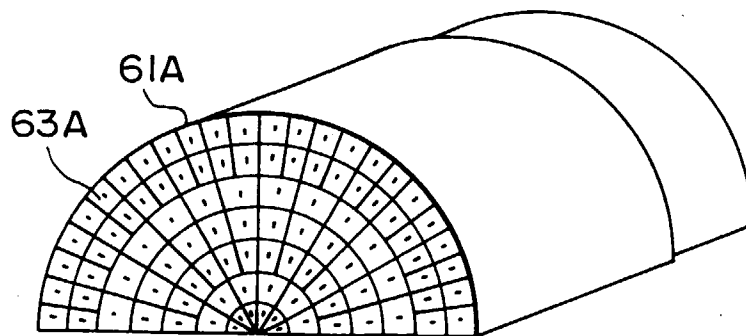


FIG. 8A FIG. 8B

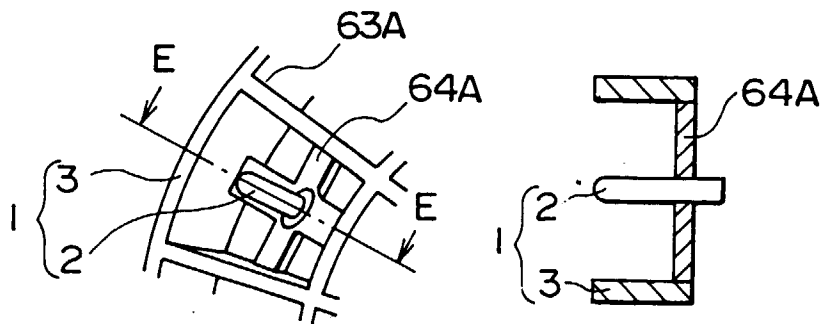


FIG. 9

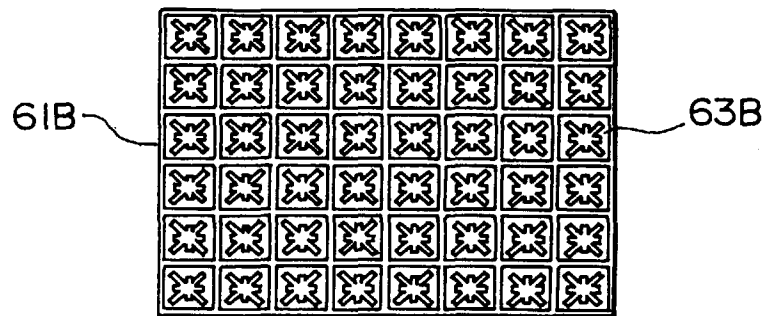


FIG. 10

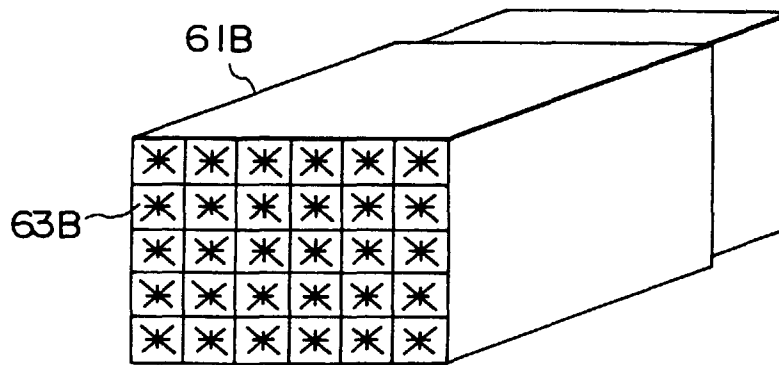


FIG. 11A FIG. 11B

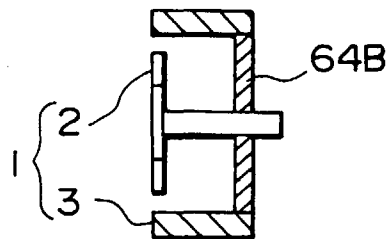
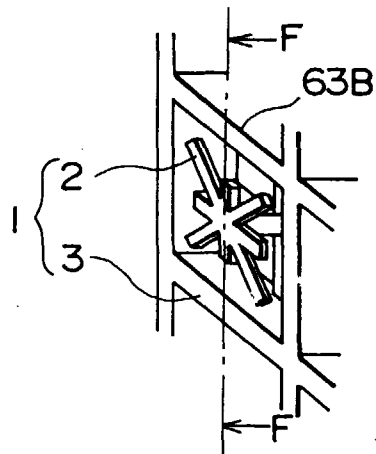


FIG. 12

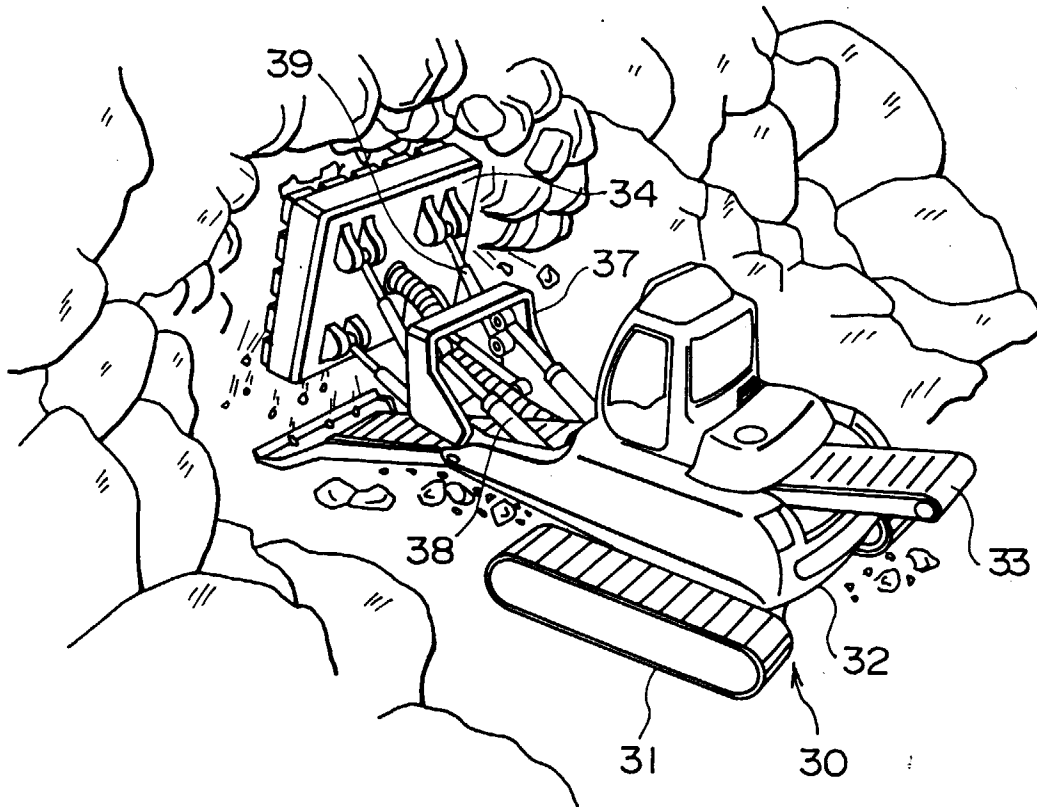


FIG. 13

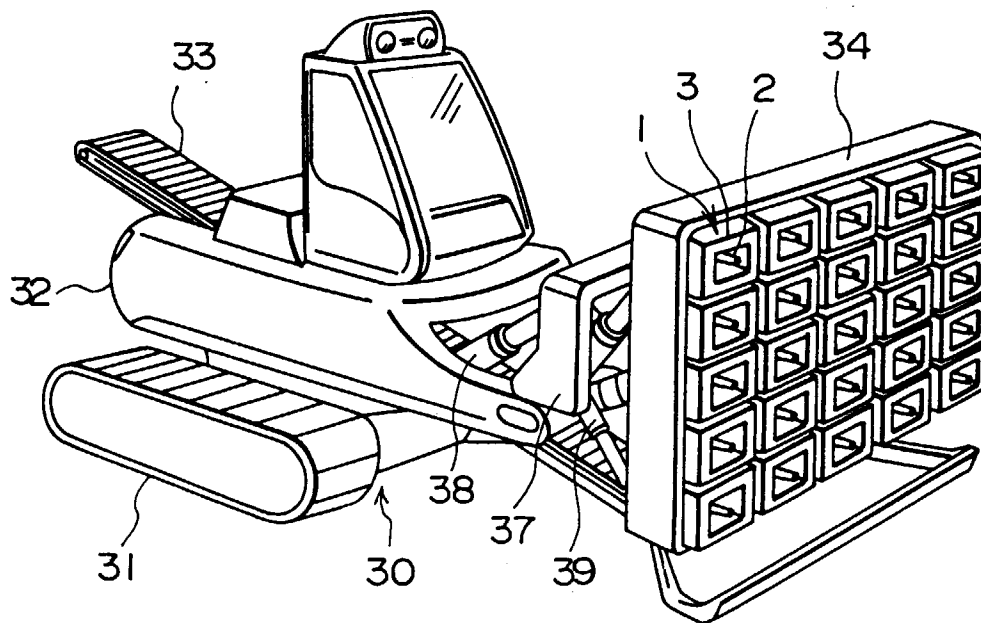


FIG. 14

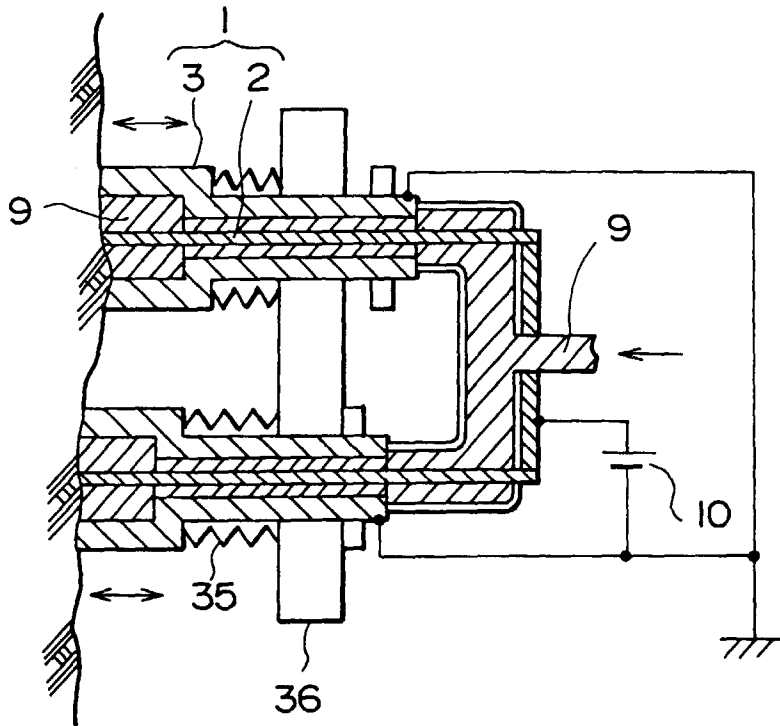


FIG. 15

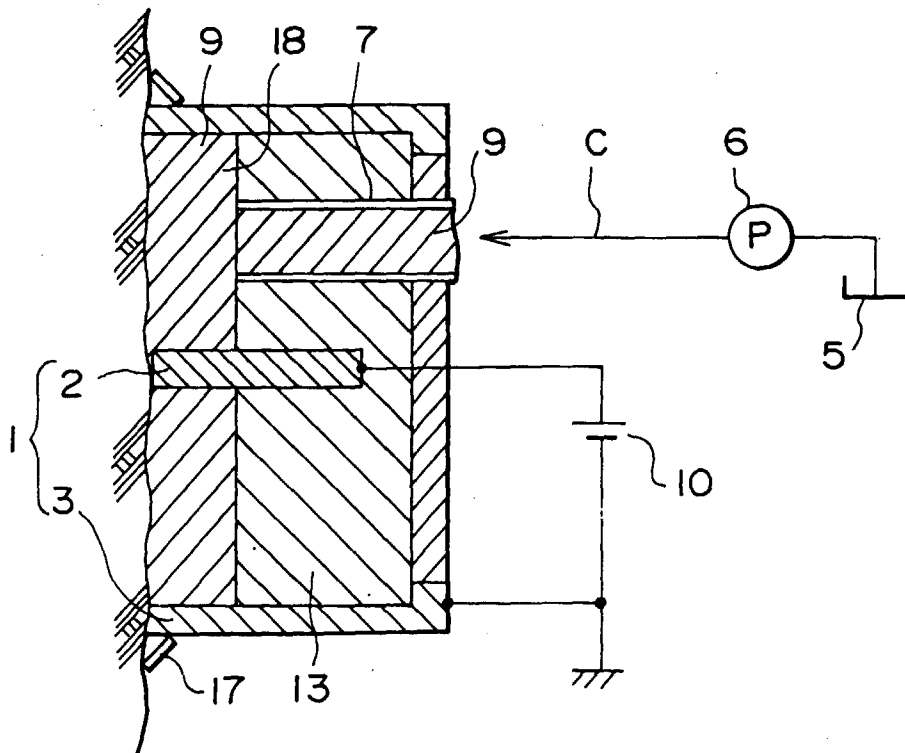


FIG. 16

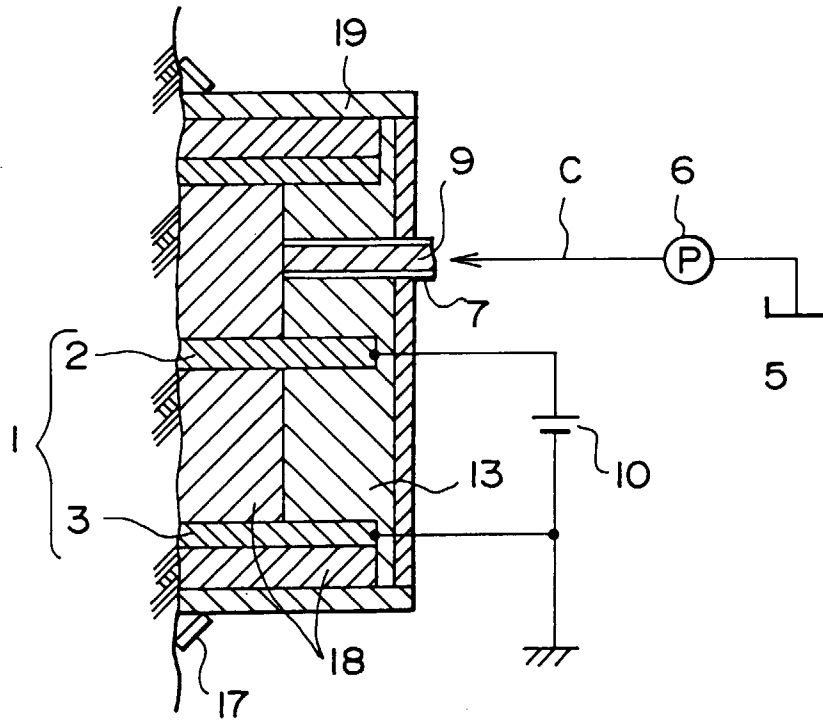


FIG. 17

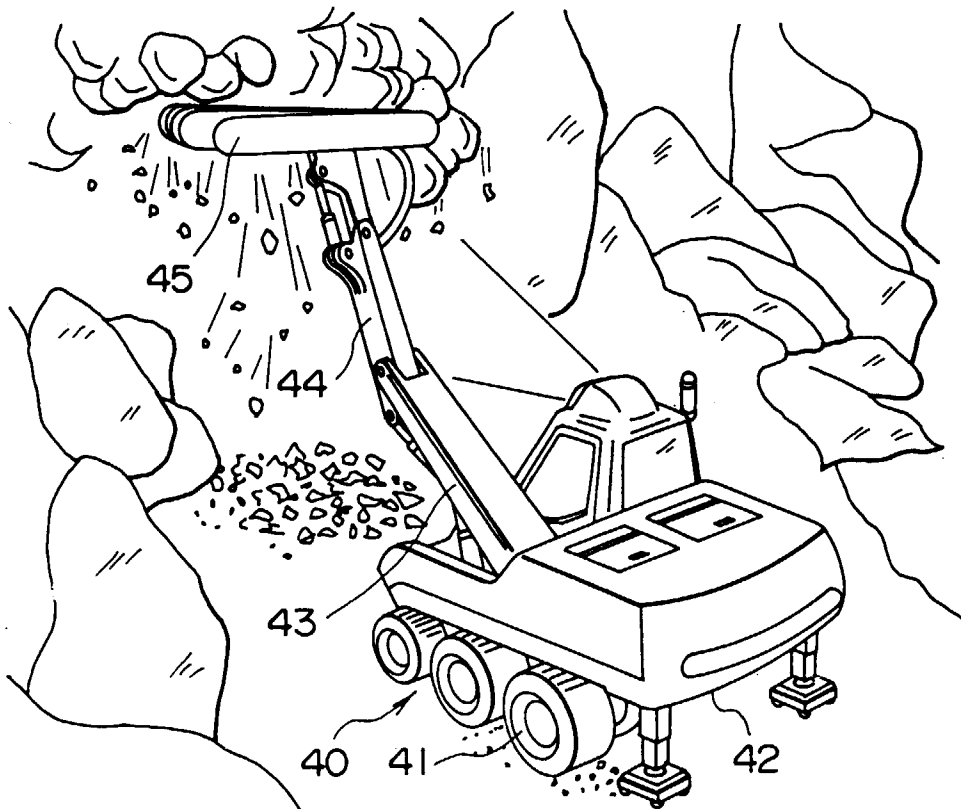


FIG. 18

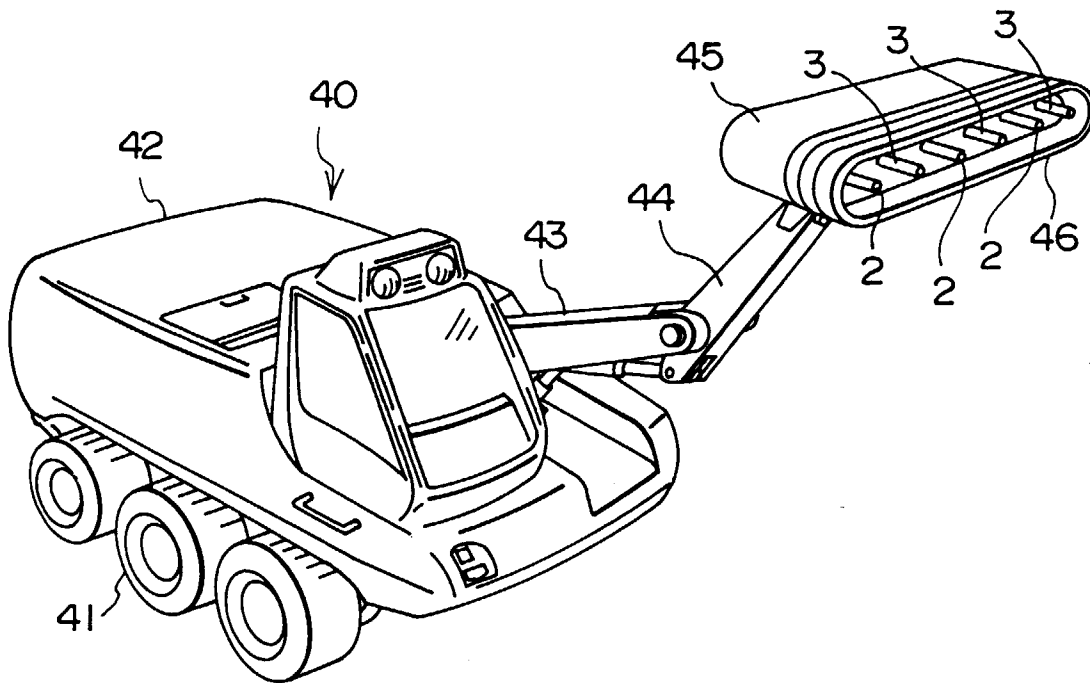


FIG. 19

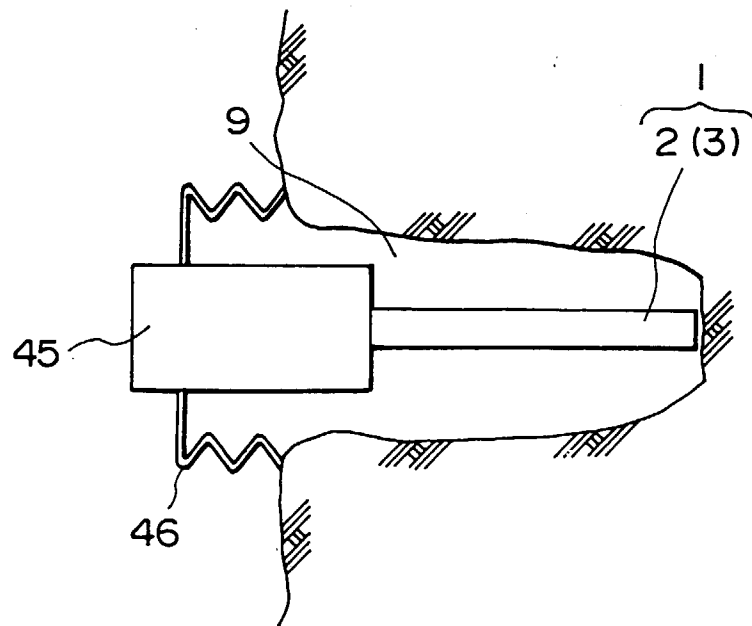


FIG. 20

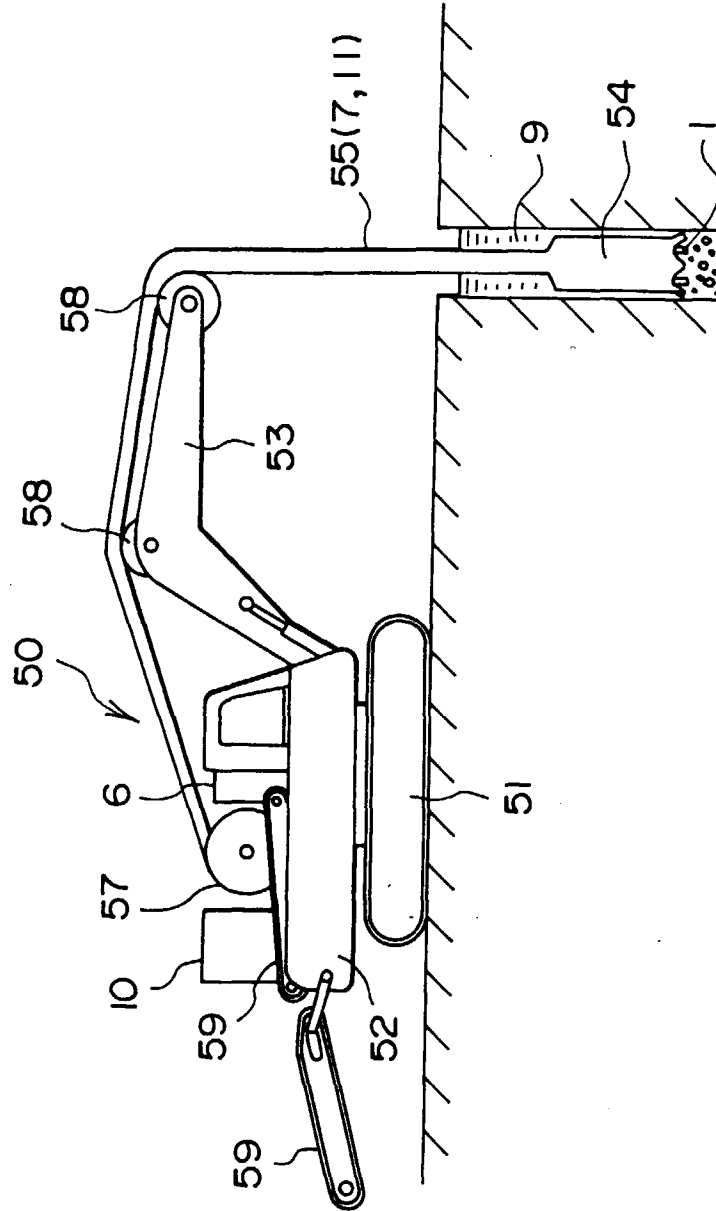


FIG. 21

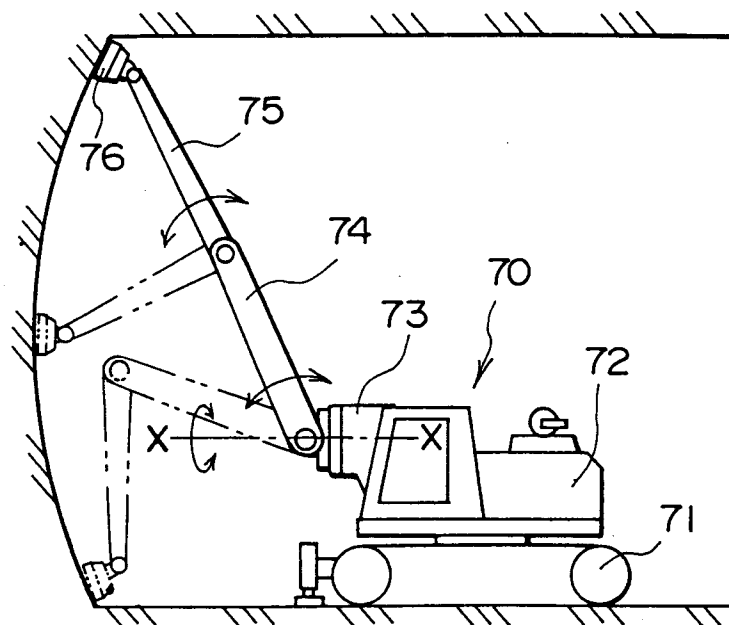


FIG. 22

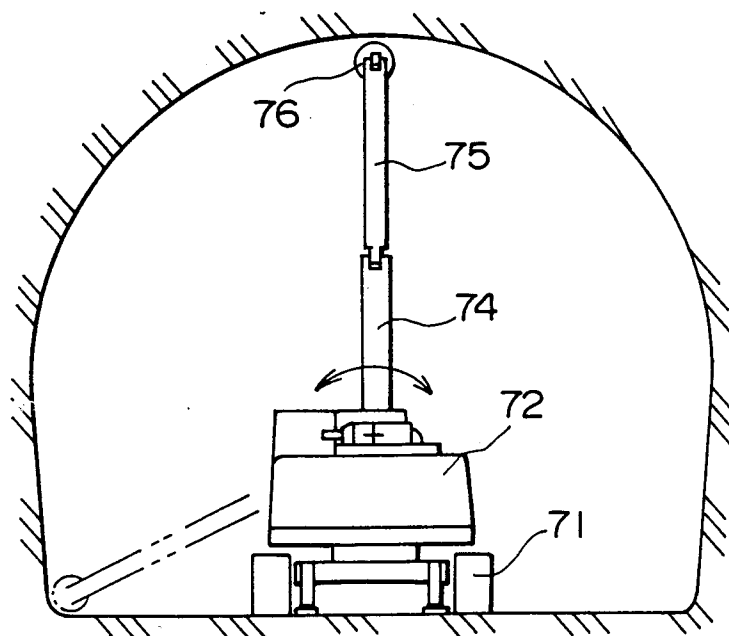


FIG. 23

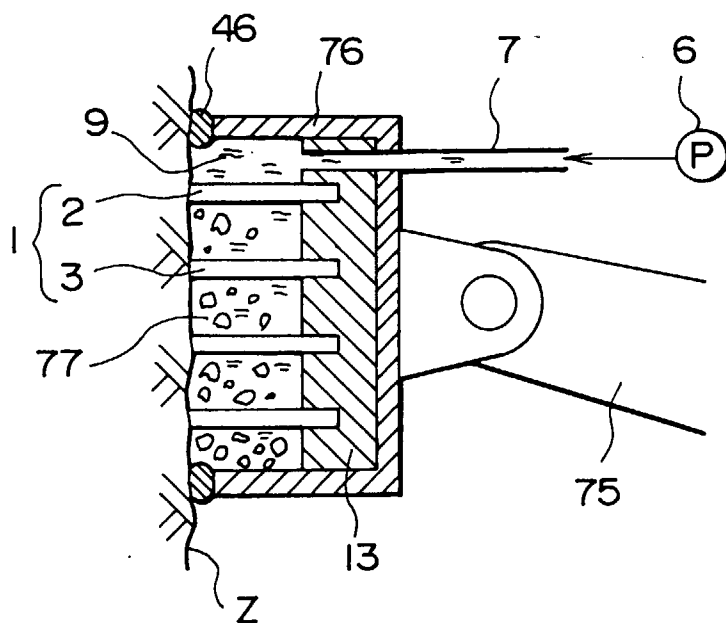


FIG. 24

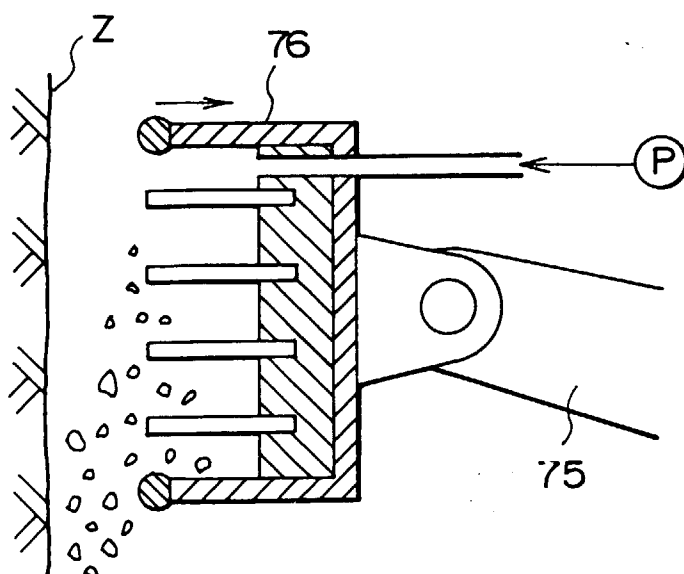


FIG. 25

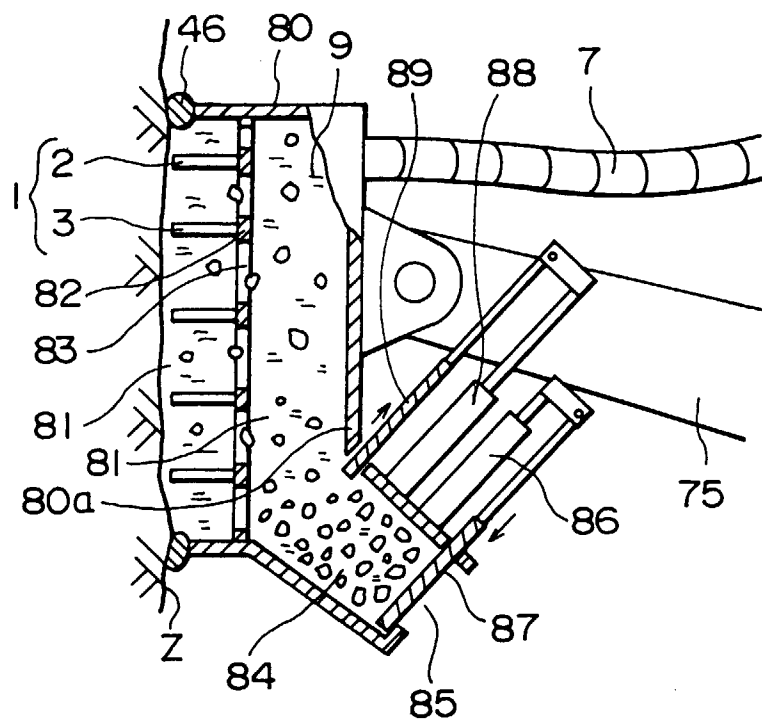


FIG. 26

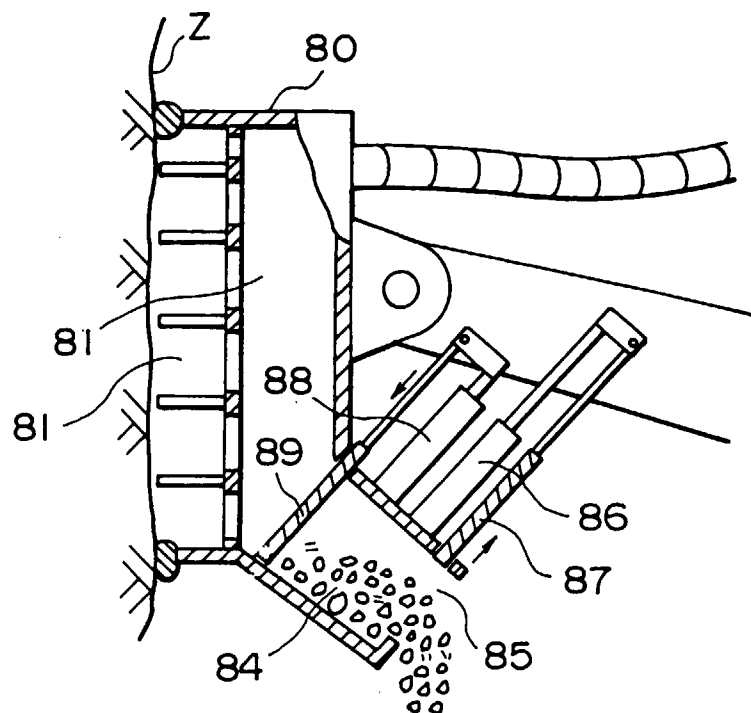


FIG. 27

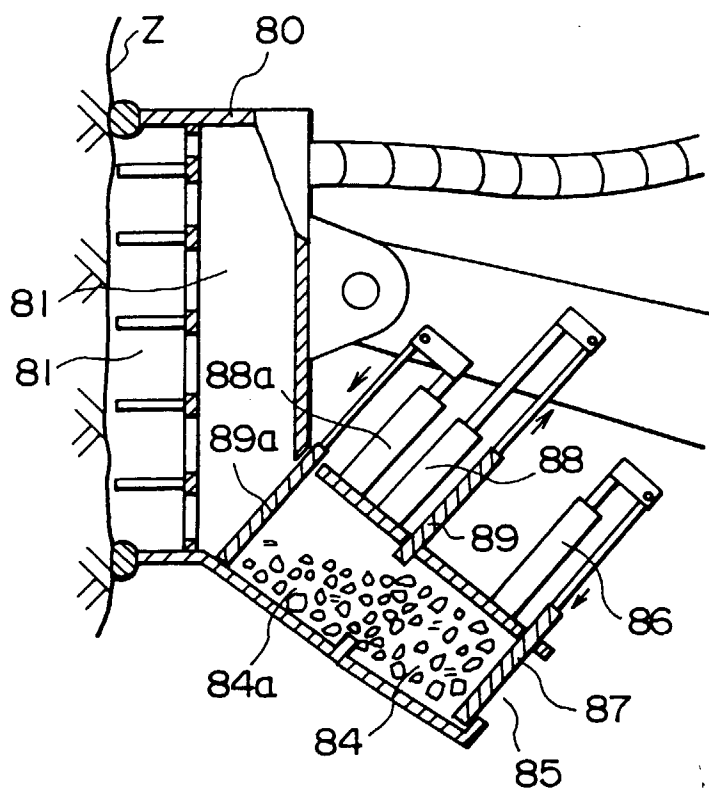


FIG. 28

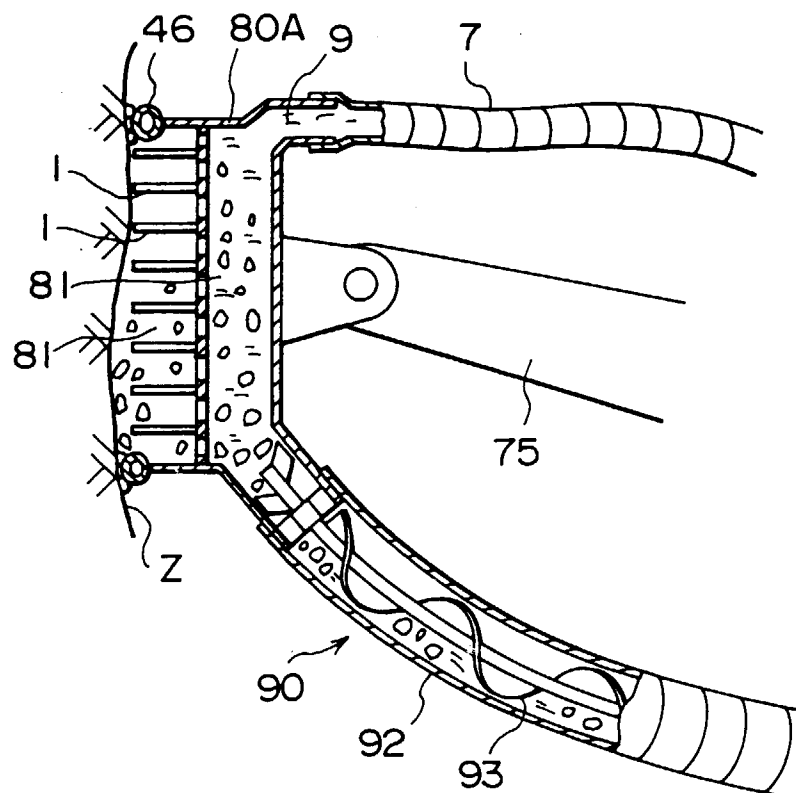


FIG. 29

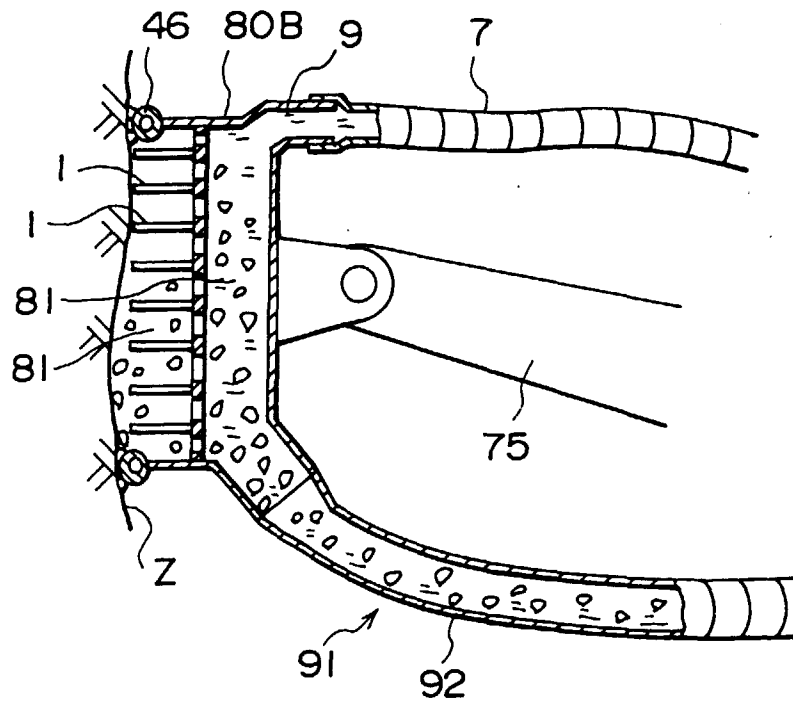


FIG. 30

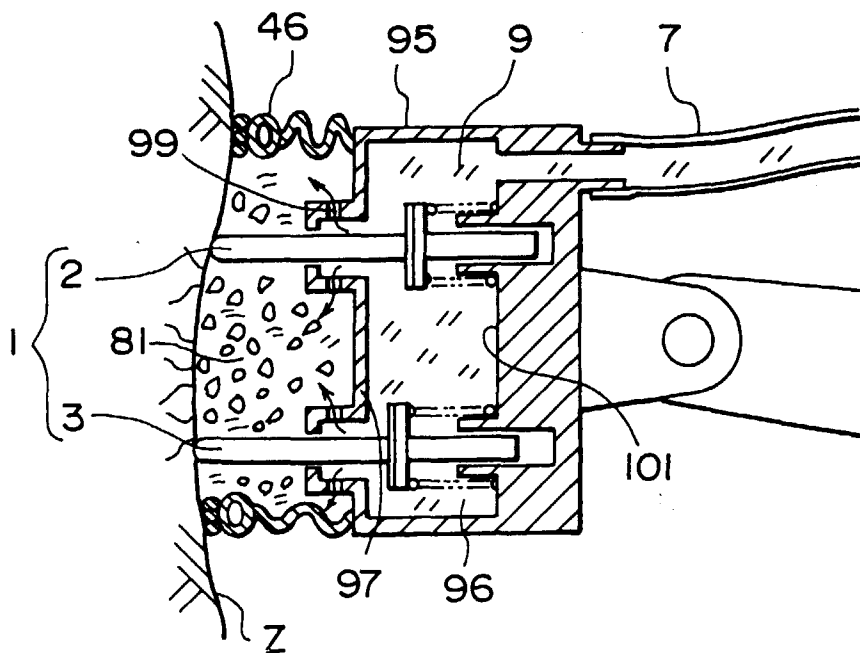


FIG. 31

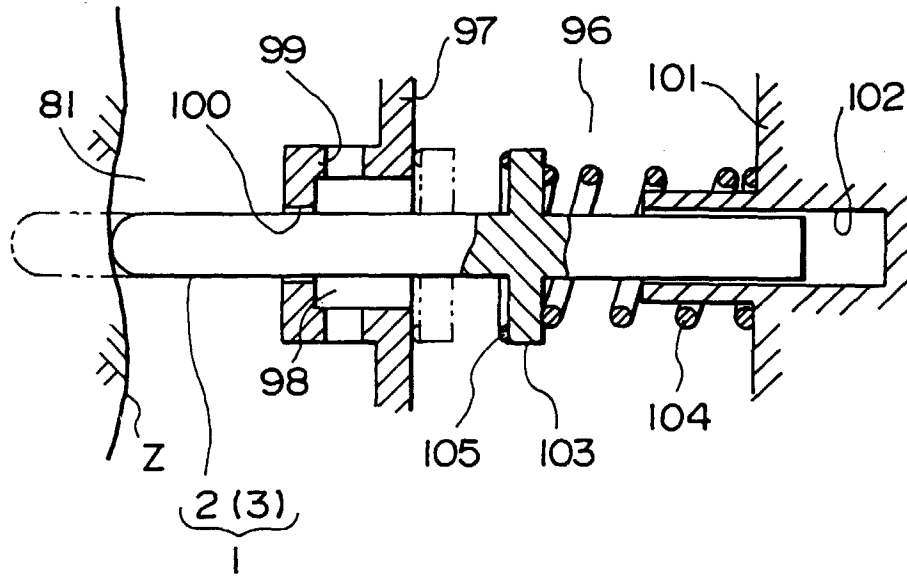


FIG. 32

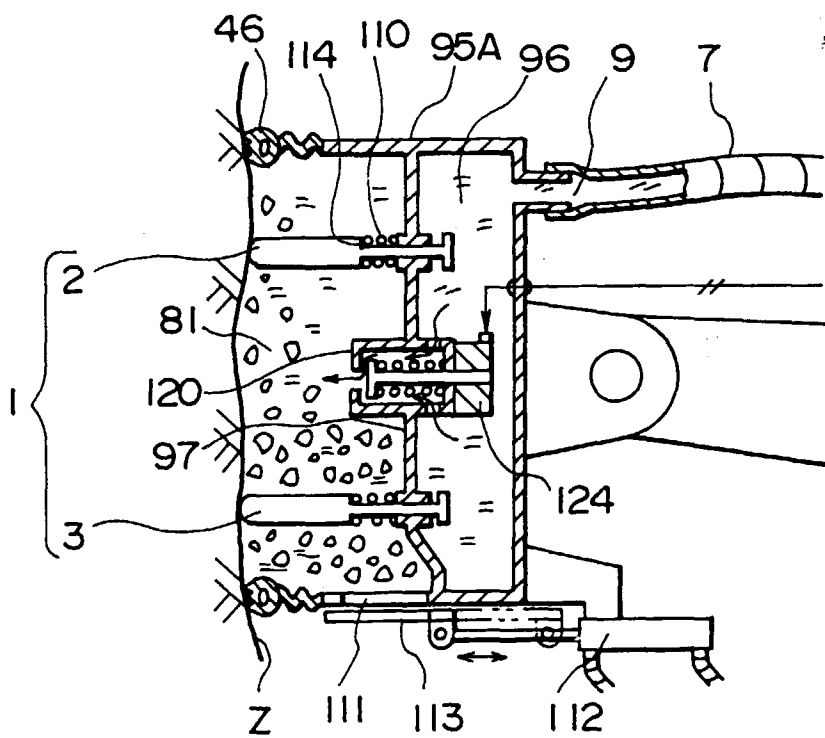


FIG. 33

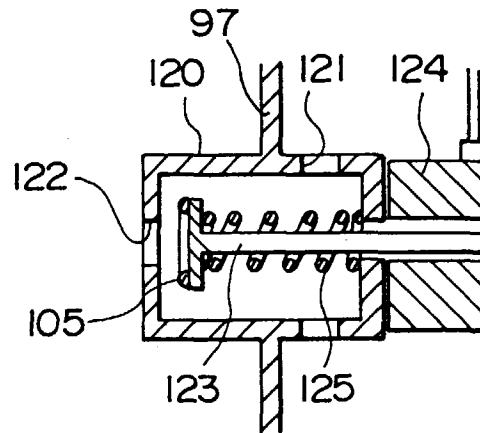


FIG. 34

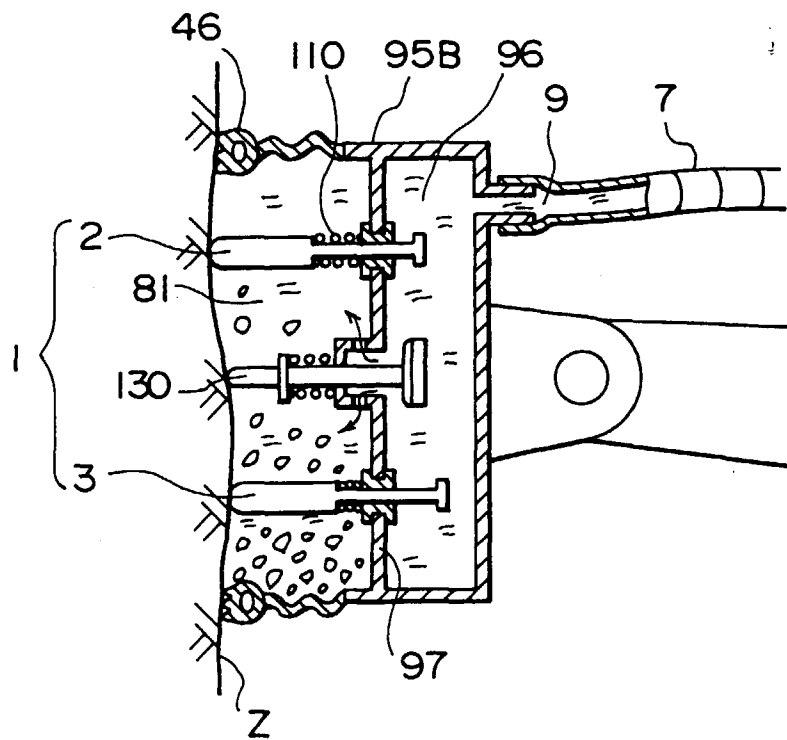


FIG. 35

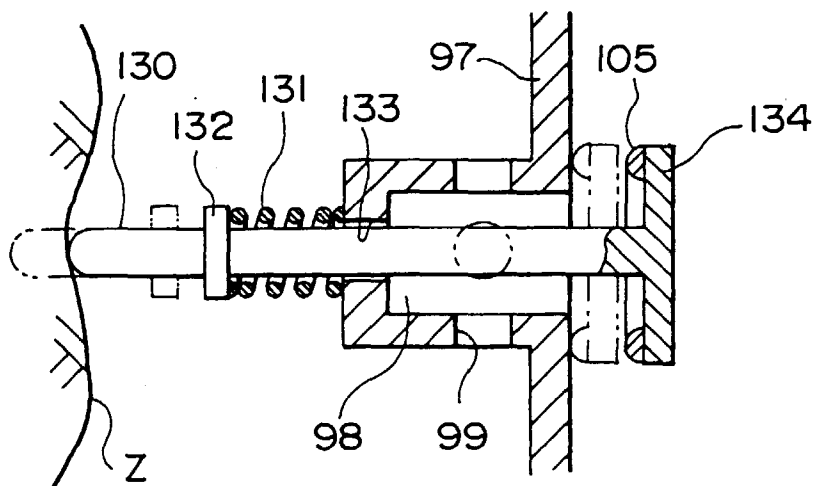
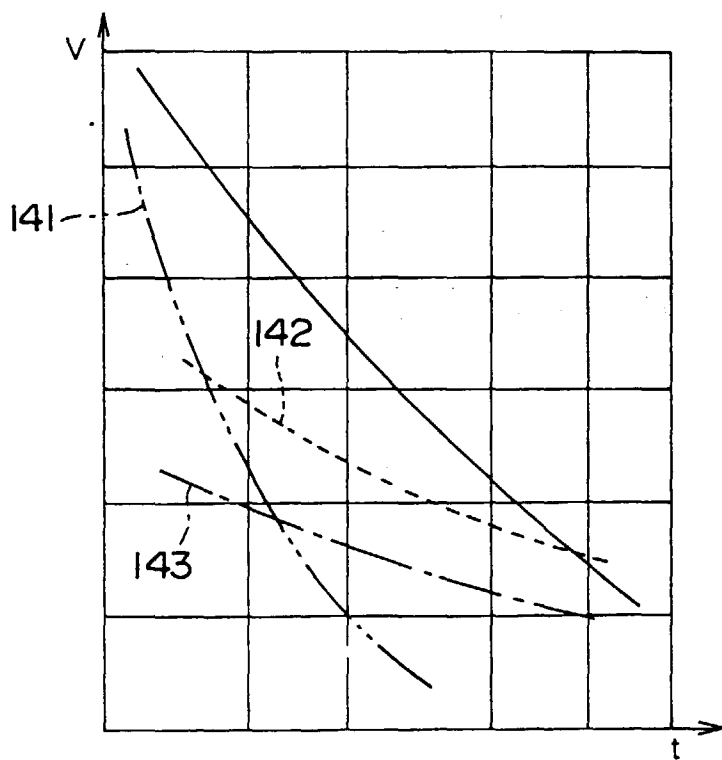


FIG. 36



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP97/02889

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl ⁶ E21C37/18, E21D9/08, E21D9/10		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
Int. Cl ⁶ E21C37/18, E21D9/08, E21D9/10		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Jitsuyo Shinan Koho 1940 - 1996 Jitsuyo Shinan Toroku Kokai Jitsuyo Shinan Koho 1971 - 1997 Koho 1996 - 1997 Toroku Jitsuyo Shinan Koho 1994 - 1997		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 62-502733, A (CEEE Corp.), October 22, 1987 (22. 10. 87) & US, 4653697, A & EP, 221155, A1 & WO, 86/06652, A1	1 - 19
A	JP, 4-222794, A (Noranda Inc.), August 12, 1992 (12. 08. 92) & US, 5106164, A & EP, 453076, B1	1 - 19
P, A	JP, 9-119283, A (ITAC Ltd.), May 6, 1997 (06. 05. 97) (Family: none)	1 - 19
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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Date of the actual completion of the international search November 6, 1997 (06. 11. 97)		Date of mailing of the international search report November 18, 1997 (18. 11. 97)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.		Authorized officer Telephone No.

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