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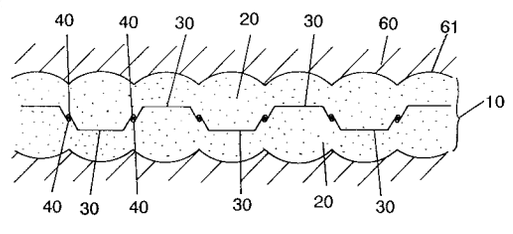
(54) Underground water cutoff wall and method of constructing the same.

(57) An underground water cutoff wall (10) comprises an underground wall (20) and a plurality of water cutoff sheets (30) made of an corrosion resistance material. The underground wall (20) comprises a binding material and an aggregate such as sand and pebbles taken by an excavator. The water cutoff sheets (30) are continuously embedded into the underground wall (20) in such a manner as to stop seepage of water. Each of the water cutoff sheets (30) is connected with the adjacent water cutoff sheet (30) through a joint portion (40) which is formed at the longitudinal side thereof. If necessary, the reinforcing elements (50) are embedded in the underground wall (20) along the water cutoff sheets (30). The underground water cutoff wall (10) of the present invention is constructed by the following method. That is, the ground is firstly evacuated to form an excavated ditch (61) therein. A mixture of the aggregate and a slurry of the binding material is cast into the excavated ditch (61) to form the underground wall (20). The water cutoff sheets (30) are inserted into the underground wall (20) until the mixture is not hardened. If necessary, the reinforcing elements (50) are also inserted into the underground wall (20) until the mixture is not hardened. Subsequently, the mixture is hardened. As a result, the underground water cutoff wall (10) has excellent corrosion resistance for stopping the seepage of water over a long time period.

FIG. 2



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BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

The present invention relates to an underground water cutoff wall for stopping seepage of water and a method of constructing the same.

2. BACKGROUND ART

An underground water cutoff wall is used for preventing a reverse flow of saltwater, or an outflow of groundwater including a harmful substance which is permeated into the ground, and also as a weir for preserving groundwater in the ground. For example, the underground water cutoff wall in the past has been constructed by the following method. That is, the ground is firstly excavated to form an excavated ditch, and then a mixture of a slurry of a binding material and an aggregate such as sand and pebbles is cast into the excavated ditch to form an underground wall. Although the underground wall comprising only the mixture of the aggregate and the binding material is capable of stopping seepage of water to some extent, there has been a problem, for example, in case that the mixing of the aggregate and the binding material is not enough. And besides, when some cracks are generated in the underground wall by a natural phenomenon such as an earthquake and so on, there is a possibility of the seepage of water from the cracks. On the other hand, another underground water cutoff wall comprises a plurality of sheet piles made of steel and the underground wall, the steel sheets being continuously embedded into the underground wall in such a manner as to stop the seepage of water. Although the sheet piles embedded in the underground wall are effective to stop the seepage of water, the sheet piles may be corroded within a long time period. Especially, when the cracks are generated in the underground wall, saltwater, or groundwater including the harmful substance, etc., flows out to the sheet piles through the cracks, so that corrosion of the sheet piles may be accelerated. Therefore, in this case, it is so difficult for the underground water cutoff wall to stop the seepage of saltwater, etc., for the long time period. As described above, there has been a serious problem with respect to the underground water cutoff wall in the past.

The present invention is directed to an underground water cutoff wall having excellent corrosion resistance for stopping seepage of water for a long time period and a method of constructing the same. That is to say, the underground water cutoff wall comprises an underground wall and a plurality of water cutoff sheets made of an corrosion resistance material. The underground wall comprises of a mixture of an aggregate such as sand and pebbles and a binding material. The water cutoff sheets are continuously embedded into the underground wall in such a manner as to stop the seepage of water. Therefore, even when saltwater or groundwater including a harmful substance is flown to the water cutoff sheets through a crack generated in the underground wall, the seepage of saltwater, etc., may be stopped by the water cutoff sheets over a long time period because the water cutoff sheets are made of the corrosion resistance material.

Therefore, it is a primary object of the present invention to provide an underground water cutoff wall having excellent corrosion resistance which is capable of stopping seepage of water over a long time period.

In the preferred embodiment of the present invention, the corrosion resistance material is selected from a synthetic resin, a ceramic and glass, etc. On the other hand, cement, or a mixture of cement and bentonite, etc., is used as the binding material. For preventing the generation of a crack in the underground water cutoff wall, it is preferred that reinforcing elements are embedded in the underground water cutoff wall. The reinforcing elements are arranged along the water cutoff sheets in the underground wall. Steel bars and/or steel sheets, etc., are used as the reinforcing elements. It is also preferred that each of the water cutoff sheets is connected with the adjacent water cutoff sheet through a joint portion which is formed at the longitudinal side thereof. Therefore, the seepage of water through a space between the water cutoff sheets can be prevented by the joint portion.

The underground water cutoff wall of the present invention is constructed in the ground by the following method. That is, the ground is firstly excavated to form an excavated ditch therein. A mixture of the aggregate and a slurry of the binding material is cast into the excavated ditch to form the underground wall. Until the mixture is not hardened, the water cutoff sheets made of the corrosion resistance material are inserted into the underground wall such that each of the water cutoff sheets is connected with the adjacent water cutoff sheet through the joint portion which is formed at the longitudinal side thereof. Subsequently, the mixture is hardened to obtain the underground water cutoff wall of the present invention. Thus constructed underground water cutoff wall is capable of stopping the seepage of water over the long time period.

Therefore, it is another object of the present invention to provide a method of constructing an underground water cutoff wall having excellent corrosion resistance which is capable of stopping seepage of water over a long time period.

Another underground water cutoff wall of the present invention is constructed in the ground by the following method. That is, the ground is firstly excavated to form the excavated ditch therein. The mixture of the aggregate and the slurry of the binding material is cast into the excavated ditch to form the underground wall. Until the mixture is not hardened, the water cutoff sheets made of the corrosion resistance material are inserted into the underground wall such that each of the water cutoff sheets is connected with the adjacent water cutoff sheet through the joint portion which is formed at the longitudinal side thereof. In addition, the reinforcing elements are inserted into the underground wall along the water cutoff sheets. Subsequently, the mixture is hardened to obtain the underground water cutoff wall of the present invention. Thus constructed underground water cutoff wall is capable of stopping the seepage of water over the long time period, and also has an increased strength thereof.

Therefore, it is a further object of the present invention to provide a method of constructing an underground water cutoff wall having excellent corrosion resistance and high strength thereof which is capable of stopping seepage of water over a long time period.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical cross sectional view of an underground water cutoff wall of a first embodiment the present invention;

FIG. 2 is a horizontal cross sectional view of the underground water cutoff wall of the first embodiment;

FIG. 3 shows a front view of a multi-shaft auger machine used for constructing the underground water cutoff wall of the present invention;

FIG. 4 shows a side view of the multi-shaft auger machine;

FIG. 5 is an horizontal cross sectional view of the underground water cutoff wall of the first embodiment;

FIG. 6 is a vertical cross sectional view of an underground water cutoff wall of a second embodiment of the present invention;

FIG. 7 is a horizontal cross sectional view of the underground water cutoff wall of the second embodiment;

FIG. 8 is a horizontal cross sectional view of an underground water cutoff wall of a modification of the second embodiment;

FIG. 9 is a vertical cross sectional view of the underground water cutoff wall of the second embodiment; and

FIG. 10 is a horizontal sectional view of the underground water cutoff wall of the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention is described in detail according to drawings appended in this specification.

At a location which is planed to prevent a reverse flow of saltwater, or an outflow of groundwater including a harmful substance which is permeated into the ground, or preserve groundwater in the ground, an underground water cutoff wall **10** of the present invention is constructed by the following method of a first embodiment. That is, the ground **60** is excavated to form an excavated ditch **61** having an optional depth and length by a multi-shaft auger machine **70**, as shown in FIGS. 3 and 4. The multi-shaft auger machine **70** contains a plurality of vertical shafts **71**. Each vertical shaft has a boring bit **72** attached on each leading end thereof, a plurality of mixing paddles **73** and auger blades **74** arranged thereon, openings **75** for injecting a slurry of a binding material such as cement milk or a mixture of cement milk and bentonite into the excavated ditch **61**. A plurality of holes are simultaneously excavated by the multi-shaft auger machine **70**. The excavating by the auger machine is continued to form the excavated ditch. And besides, the auger machine is capable of injecting the slurry of the binding material into the holes while the holes are being excavated thereby. As the vertical shafts **71** rotate, the mixing paddles blend thus injected slurry with an aggregate such as sand and pebbles excavated by the auger machine **70** in situ. By repeating the like procedure, an underground wall **20** comprising the aggregate and the binding material is formed in the excavated ditch **61**. The vertical cross section of the underground wall **20** is a rectangle, as shown in FIG. 1. Until the binding material is not hardened, a plurality of water cutoff sheets **30** made of an corrosion resistance material are continuously inserted in the underground wall **20** in such a manner as to stop seepage of water, so that the underground water cutoff wall **10** is obtained, as shown in FIG. 1. The corrosion material is selected from a synthetic resin, a ceramic and glass, etc. Since each of the water cutoff sheets **30** is connected with the adjacent water cutoff sheet **30** through a joint portion **40** which is formed at the longitudinal side thereof, as shown in FIG. 2, the seepage of water from the space between the adjacent water cutoff sheets can be stopped by the joint portion **40**. Of course, a shape of the water cutoff sheet **30** is not limited to that shown in FIG. 2. As described above, the underground water cutoff wall **10** of the present invention is used for preventing the reverse flow of

saltwater, or the outflow of groundwater including the harmful substance, or as a weir for preserving groundwater in the ground. For example, in case of using the underground water cutoff wall for preventing the outflow of groundwater including the harmful substance, it is preferred that the underground water cutoff wall is constructed so as to surround a location **62** having an industrial waste and toxic waste with the underground water cutoff wall **10**, as shown in FIG. 4. As a result, the outflow of groundwater including the harmful substance can be prevented by thus constructed water cutoff wall **10**.

An underground water cutoff wall of a second embodiment of the present invention is constructed according to the same method of the first embodiment except that reinforcing elements **50** are also inserted into the underground wall **20** along the water cutoff sheets **30** until the binding material in the underground wall is not hardened. The reinforcing elements **50** are made of steel, etc. If necessary, steel sheets, steel bars **51** and/or steel reinforcements having all kinds of shapes are utilized as the reinforcing elements **50**. Of course, it is not concerned that the steel bars **51** are embedded into the underground wall **20** at a predetermined interval, as shown in FIG. 7, or sectionally embedded in the underground wall. In the second embodiment, the reinforcing elements **50** is continuously embedded into the underground wall **20** along the water cutoff sheets **30**. Each of the reinforcing elements is connected with the adjacent reinforcing element through a joint portion which is formed at the longitudinal side thereof. As a result, the underground water cutoff wall **10** of the second embodiment has excellent corrosion resistance and an increased strength thereof, which is capable of stopping the seepage of water with the water cutoff sheets **30** and the reinforcing elements **50** which are continuously embedded therein. When the reinforcing elements **50** are continuously embedded in parallel with the water cutoff sheets **30** into the underground wall **20**, stress occurring from a natural phenomenon such as an earthquake and so on, can be efficiently borne by the reinforcing elements **50**, so that the generation of a crack in the water cutoff sheets may be prevented. In case of using the underground water cutoff wall for preventing the reverse flow of saltwater, or as the weir for preserving groundwater in the ground, it is preferred that the water cutoff sheets **30** are embedded into the underground wall **20** at the upstream side of the reinforcing elements **50** in the direction of the reverse flow of saltwater or a flow of groundwater. On the other hand, when the underground water cutoff wall **10** is utilized for preventing the outflow of groundwater including the harmful substance, it is preferred that the underground water cutoff wall **10** is constructed so as to surround the location **62** having the industrial waste and toxic waste therewith, and also the water cutoff sheets **30** are embedded into the underground wall **20** between the location **62** and the reinforcing elements **50**, as shown in FIGS. 9 and 10. As a result, since the reinforcing elements **50** are spaced away from groundwater, saltwater, or groundwater including the harmful substance by the water cutoff sheets **30**, it may be expected that the underground water cutoff wall **10** maintains the increased strength thereof over a long time period without corrosion of the reinforcing elements **50**.

The features disclosed in the foregoing description, in the description, in the claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

LIST OF REFERENCE NUMRERALS

10	underground water cutoff wall
20	underground wall
30	water cutoff sheet
40	joint portion
50	reinforcing element
51	steel bar
60	the ground
61	excavated ditch
62	location
70	multi-shaft auger machine
71	vertical shaft
72	boring bit
73	mixing paddle
74	auger blade
75	opening

Claims

1. An underground water cutoff wall comprising an underground wall and a plurality of water cutoff sheets made of an corrosion resistance material;
said underground wall comprising an aggregate and a binding material; and
said water cutoff sheets are continuously embedded into said underground wall in such a manner as to stop seepage of water.

2. An underground water cutoff wall as set forth in claim 1, including reinforcing elements which are embedded into said underground wall along said water cutoff sheets.

3. An underground water cutoff wall as set forth in claim 1 or 2, wherein each of said water cutoff sheets is connected with the adjacent water cutoff sheet through a joint portion which

is formed at the longitudinal side thereof.

4. A method of constructing an underground water cutoff wall in the ground comprising the steps of;

excavating the ground to form an excavated hole therein;

casting a mixture of an aggregate and a slurry of a binding material into the excavated hole to form an underground wall;

inserting a plurality of water cutoff sheets made of an corrosion resistance material into said underground wall until the mixture is not hardened, each of said water cutoff sheets being connected with the adjacent water cutoff sheet through a joint portion which is formed at a longitudinal side thereof: and

hardening the mixture to obtain said underground water cutoff wall.

5. A method of constructing an underground water cutoff wall in the ground comprising the steps of;

excavating the ground to form an excavated hole therein;

casting a mixture of an aggregate and a slurry of a binding material into the excavated hole to form an underground wall;

inserting a plurality of water cutoff sheets made of an corrosion resistance material into said underground wall until the mixture is not hardened, each of said water cutoff sheets being connected with the adjacent water cutoff sheet through a joint portion which is formed at the longitudinal side thereof;

inserting reinforcing elements into said underground wall until the mixture is not hardened, said reinforcing elements being arranged along said water cutoff sheets in the underground wall: and

hardening the mixture to obtain said underground water cutoff wall.

FIG. 1

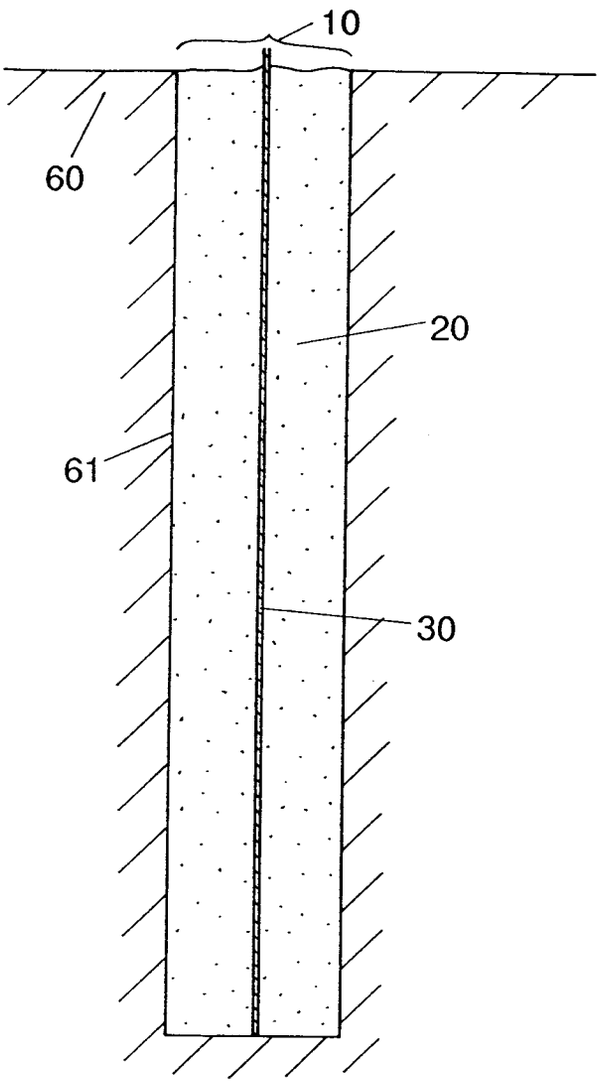


FIG. 2

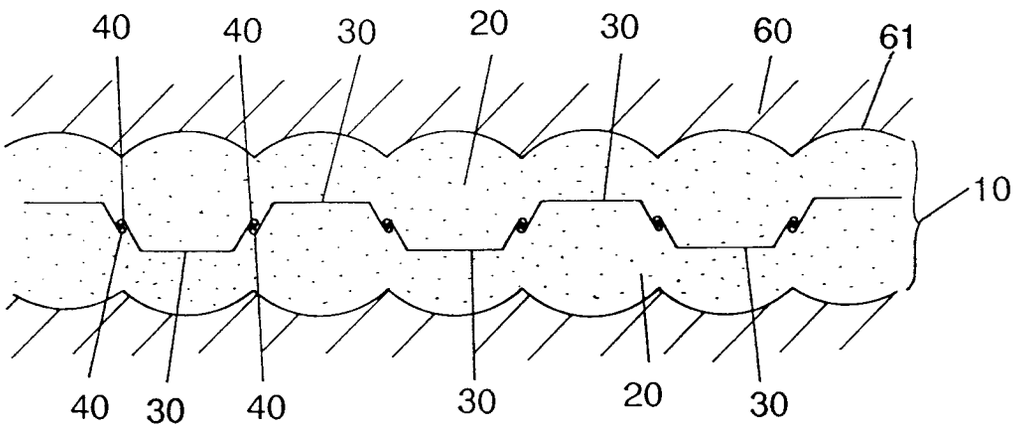


FIG. 3

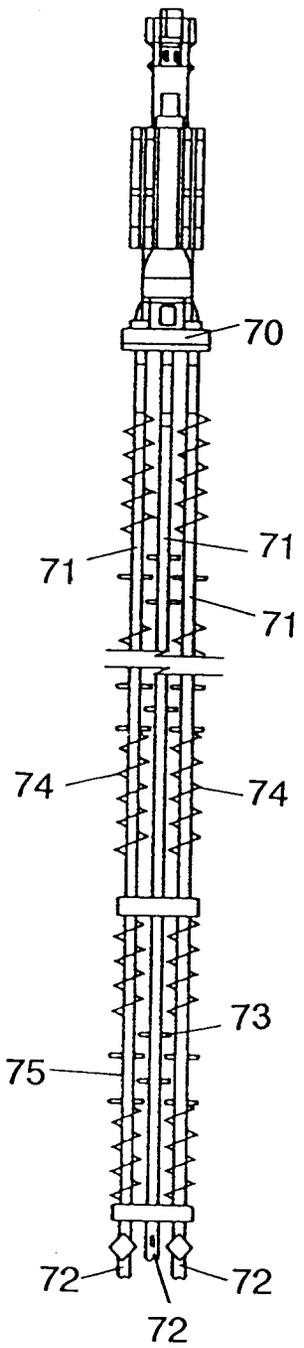


FIG. 4

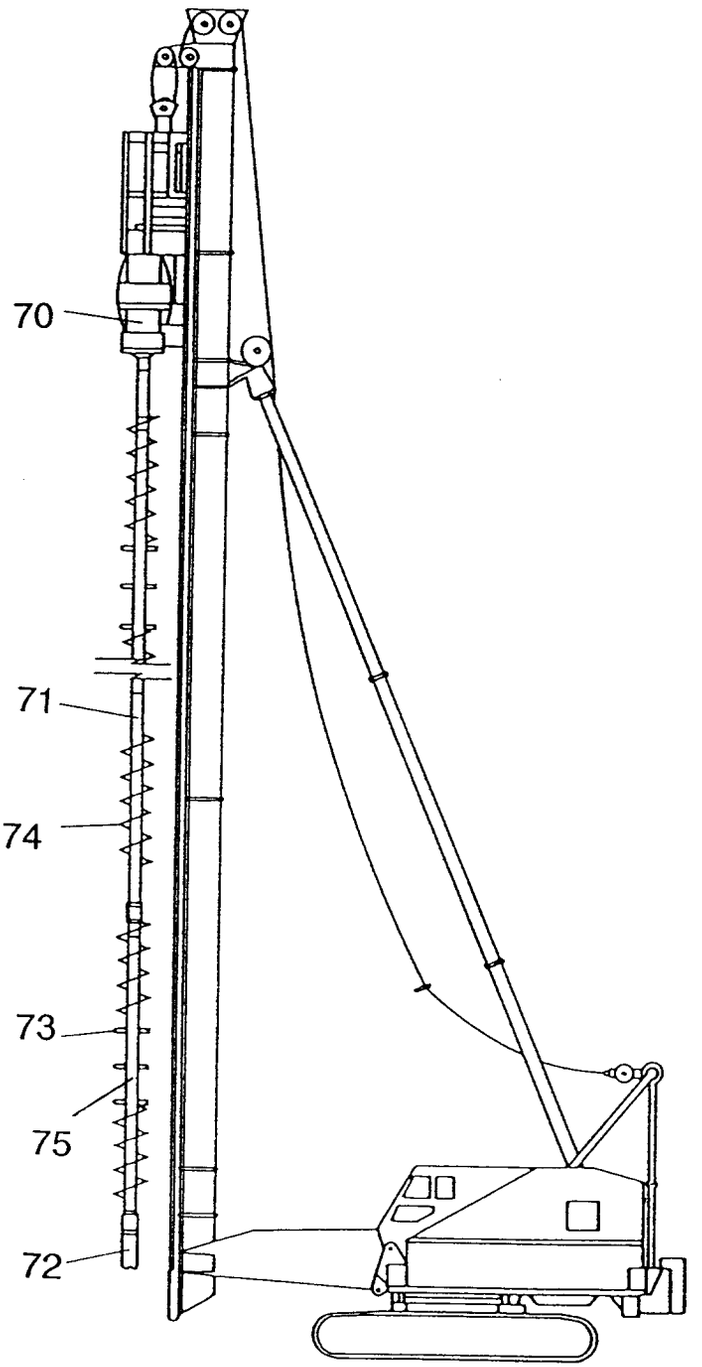


FIG. 5

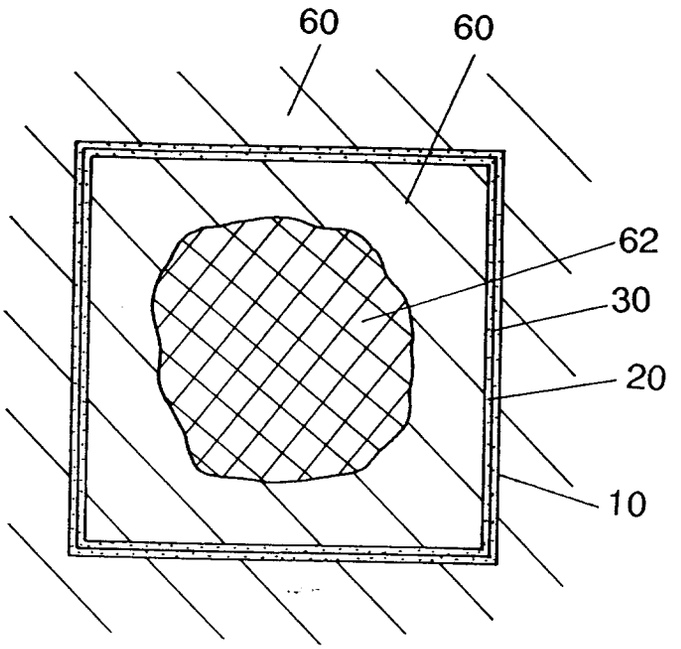


FIG. 6

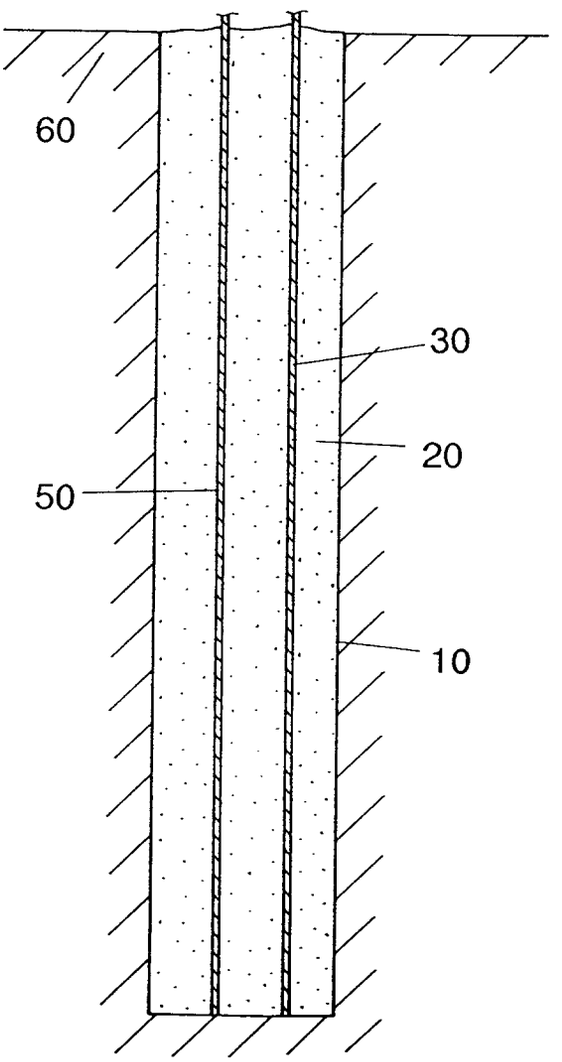
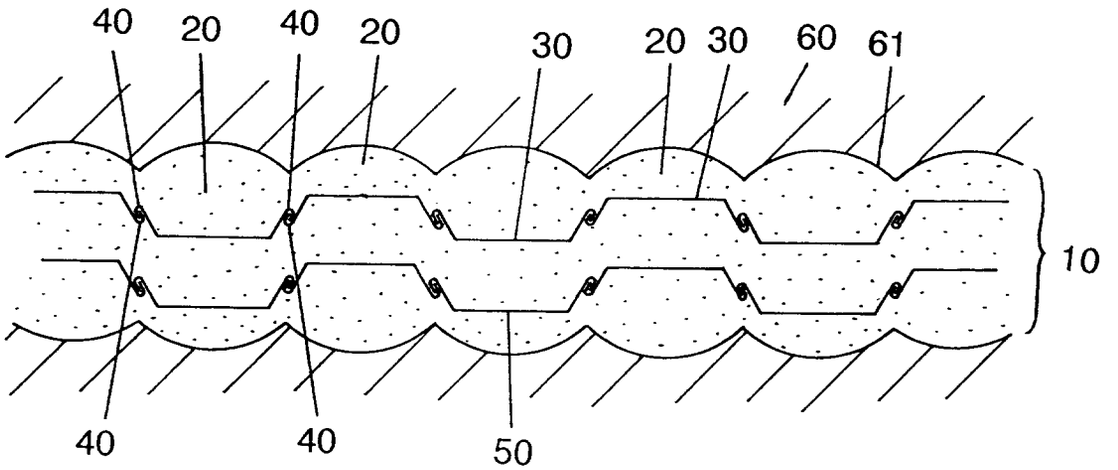


FIG. 7


40
20
40
20
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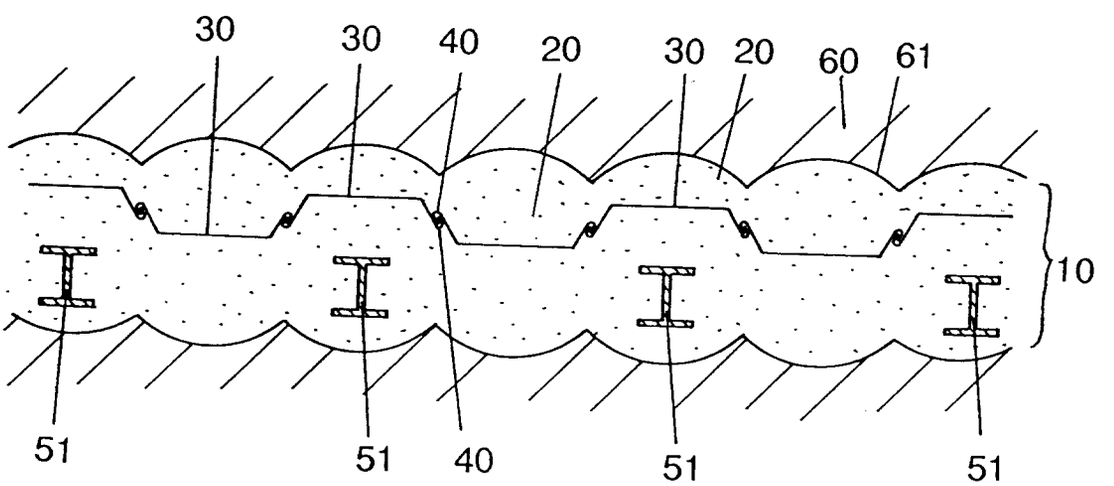
61
10
40
40
50

FIG. 8


30
30
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61
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51
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40
51
51

FIG. 9

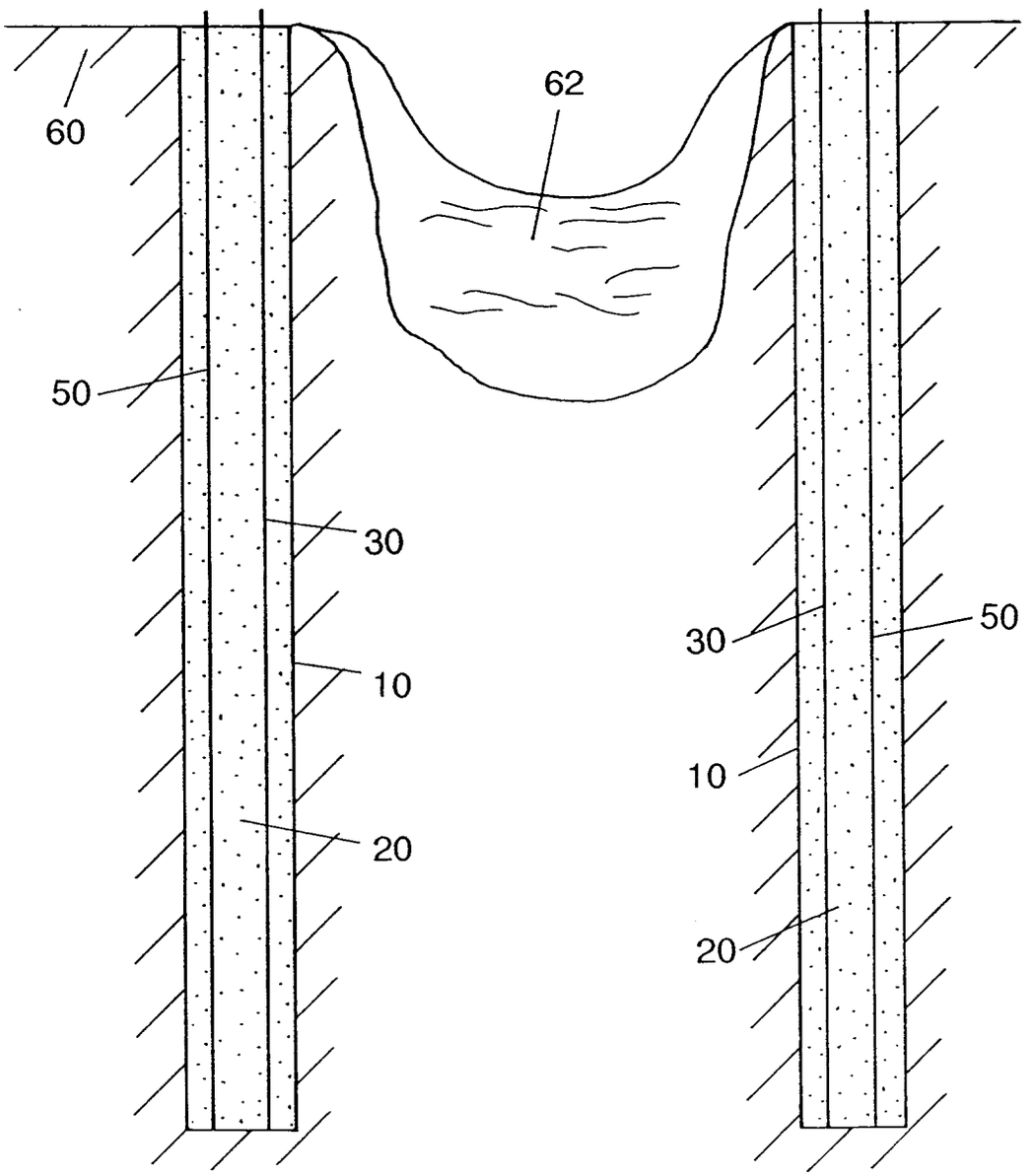
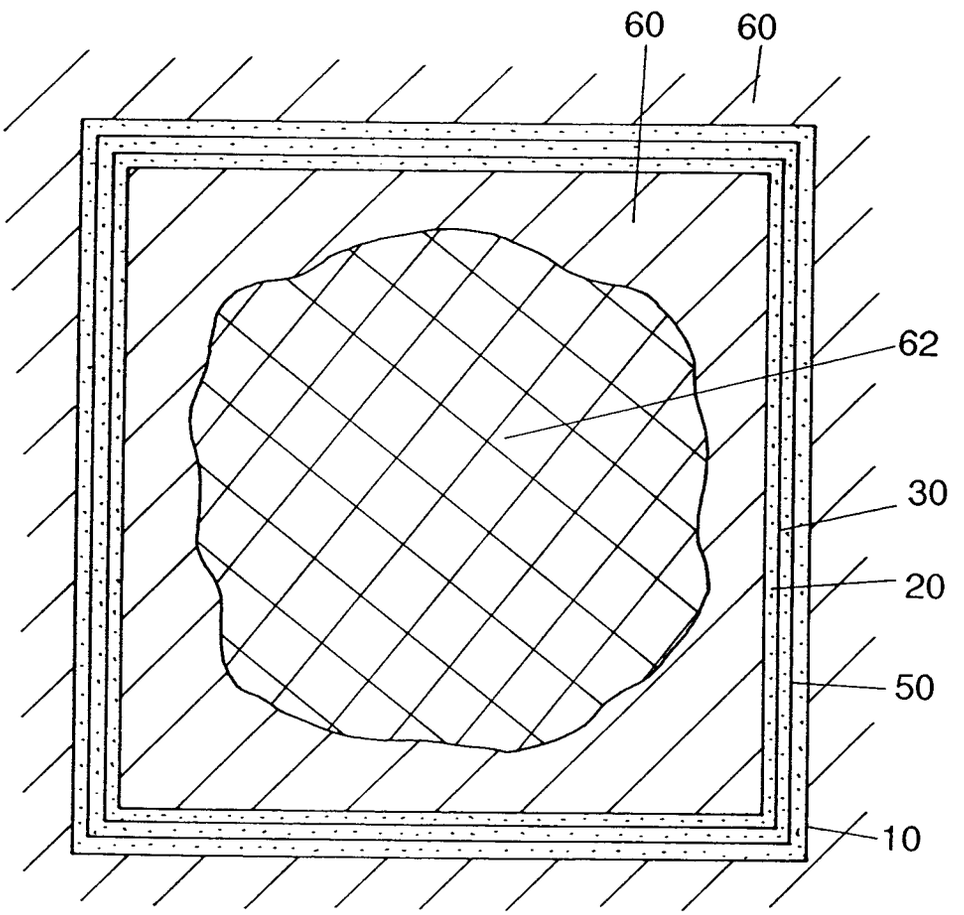


FIG. 10



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 10 1398

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 139 100 (KABUSHIKI KAISHA ASK KENKYUSHO) * page 6, line 19 - page 11, line 6; figures 1-9,12,13 *	1-5	E02D19/18
A	US-A-4 909 674 (KONNO ET AL.) * column 5, line 14 - column 7, line 48; figures 1,18-35 *	1-5	
A	NL-A-8 502 844 (DIRK VERSTOEP B.V.)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 JUNE 1993	TELLEFSEN J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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