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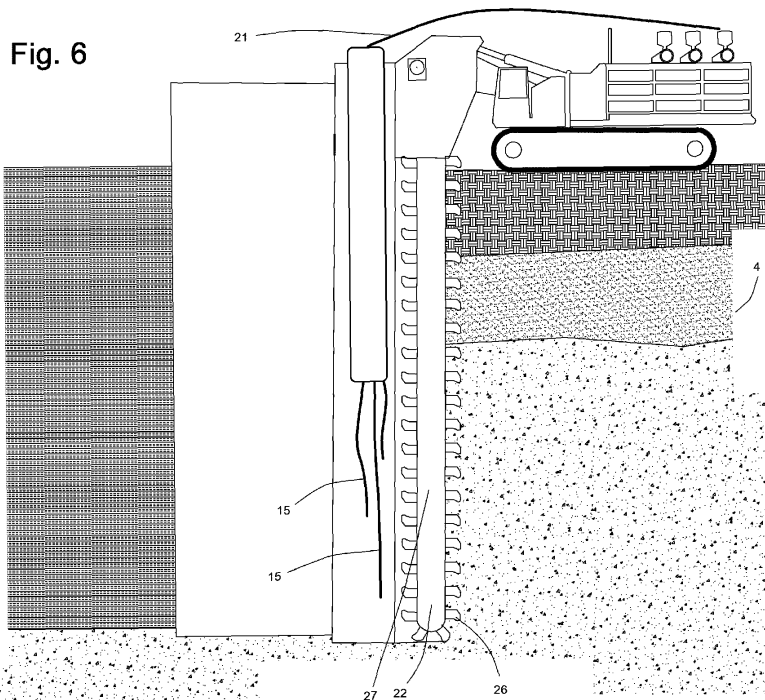
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(54) **A METHOD AND DEVICE FOR PROVIDING A PIPING PROTECTION SYSTEM IN A DIKE BODY**

(57) The invention relates to a method for making a barrier screen in a dike body for preventing transport of soil particles, said barrier screen being positioned substantially standing and extending in a longitudinal direction of said dike body, wherein in said method said barrier screen is obtained by mechanically mixing soil that is

already present in said dike body with a binder. The method is characterized in that it comprises the step of displacing a chain cutter (27) along the trajectory of the barrier screen (11) to be made through the dike body (1) and mixing the soil present and the binder (15) as well as inserting a cloth (30) into the mixed soil.



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Description

[0001] The invention relates to a method and a device for making a barrier screen in a dike for strengthening said dike.

[0002] In the state of the art, dikes are known that comprise a dike body extending between a land area and a water area, said dike body comprising a longitudinal barrier screen that is oriented substantially standing, for preventing soil particles to be transported through said dike body.

[0003] A strengthened dike body as aimed by the present invention provides the advantage that the area protected by the dike in some instances can be reduced, with the consequence that closer to the dike, or even on the dike, building will become allowed. Hence, the economic value will be improved drastically.

[0004] The use of a continuous barrier screen in a dike body is to prevent weakening of the dike by tunnel shaped spaces under the dike. Without such barrier screen soil particles may flow under the dike together with seepage water due to a height difference between water at the outer dike part of the dike and the landbased part of the dike. The tunnel shaped spaces may eventually lead to weakening or breakthrough of the dike. This problem of weakening of a dike body due to tunnel shaped spaces is identified as "piping".

[0005] In the state of the art the piping problem is obviated by means of civil technical solutions. For example, barrier screens may be provided inside the dike body so as to stop seepage water with soil particles. These known barrier screens are made of sheet pilings manufactured from concrete or steel.

[0006] A disadvantage of the use of steel sheet pilings in a dike for preventing the piping problem is that said piling must be forced into the ground by using high power equipment and that generates vibrations that may lead to damage in the surroundings and/or in the dike body. Such method also generates lots of noise disturbances in the surroundings. Also, the costs of this method for placing sheet pilings is very high.

[0007] In case of a concrete piling a first step consists of making a trench in which concrete is to be poured. Such method requires the use of many different apparatuses and devices; also, transport of equipment is cumbersome and complex.

[0008] When the seal is made in the landbased part of a dike body, the risk of cumulating water is obtained at the landbased part of the dike. Since a sheet piling acts sealingly, this will result in accumulation of water inside said dike body. Such leads to saturation of the dike and swelling of water between the sheet piling and the dike body. So as to prevent occurrence of this an additional relief system may be necessary, comprising drainpipes for draining said seepage water.

[0009] According to an aspect, the invention aims at providing a dike of the art mentioned in the preamble that can be improved without the disadvantages stated

above.

[0010] According to an aspect of the present invention it is aimed at providing a method for improving a dike body at least without part of the disadvantages as mentioned above.

[0011] The invention provides for a method for making a barrier screen in a dike body for preventing transport of soil particles, said barrier screen being in a substantially standing position and extending in a longitudinal direction of said dike body, wherein the barrier screen is made by mechanically mixing dike body's soil that is already present at the barrier screen's position with a binder.

[0012] The invention is characterized in that it comprises the step of displacing the chain cutter along the trajectory of the barrier screen to be made through the dike body and mixing the soil present and the binder as well as inserting a cloth into the mixed soil. The device may also be identified as a slot cutter. In this description the term chain cutter will be used predominantly.

[0013] By providing a barrier screen being embodied from a mixture of binder and soil that is already present in the dike body, supply and discharge of several components and building materials for making the barrier screen can be reduced. More in particular, by using the soil that is already present in the dike body, a barrier screen may be made in the dike body without firstly making a trench or urging a piling sheet in the dike body. Furthermore, the costs of such barrier screen are substantially less than the costs for making a steel sheet piping. Inserting the cloth provides the advantage that the degree of porosity may be set accurately whereas at all times an adequate blocking of seepage water is ensured.

[0014] The costs of the system according to the invention are considerably less than when using steel sheet piping, up to twenty time less costly.

[0015] The mixture of soil and binder in the dike body can be used for providing the dike body material a firm, homogeneous and cohesive granular structure, that is to say a structure of mutually bonded grains. Such granular structure serves as the barriers screen.

[0016] Preferences of the invention will be mentioned hereafter, wherein advantages will become clear from this description.

[0017] It is preferred that said cloth is provided at substantially the height of the mixed soil, so as to have a complete control of the degree of porosity along the height of the screen. Piping usually is obtained along a restricted distance below the dike, such that is usually not necessary to provide the cloth at the complete height. On the contrary, the complete dike body is strengthened when the cloth extends along the complete height of the dike. However, in cases applicable it may be useful to provide the cloth at substantially the full height of the barrier screen.

[0018] The cloth is preferably positioned behind the chain cutter into the mixed soil, enabling a quick method.

[0019] So as to obtain a permeability or water in said barrier screen, said cloth has a porosity with a permeability for at least partially passing water. Such has the advantage that a small amount of binder may be added so as to obtain at least a porous mixture of soil material and binder and wherein the cloth is permeable or water as well but impermeable to soil particles.

[0020] A strong and durable barrier screen is obtained when said cloth is incorporated inside said mixture of soil material and binder, especially wherein said cloth is incorporated in the center of the mixed soil.

[0021] A quick and efficient method for making a barrier screen is obtained wherein the chain cutter is displaced substantially horizontally through said dike body for making a continuous barrier screen extending longitudinal with respect to said dike body. For example, the chain cutter may be connected to a caterpillar vehicle that is embodied for being transported along the dike body and for displacing the chain cutter substantially horizontally through said dike body, so as to mix said dike's soil material with binder. To that end, the device will comprise a binder container and provisions for feeding said binder to the machined soil material.

[0022] According to a further aspect, the invention therefore relates to a device for making a barrier screen in a dike body, provided with a cutter comprising soil cutting and milling chisels, a binder container, and a feeding supply for, upon said cutting method, feeding binder from said binder container to the chisels, wherein said cutter comprises a chain cutter for cutting and milling soil material and mixing same with a binder, said device further being embodied for inserting a cloth in said mixture of cut and milled soil material and binder.

[0023] A further preferred embodiment relates to a device comprising a soil transporting device for inserting any soil material that is spilled on the dike's surface by the chain cutter into the dike body, said spilled material optionally being mixed with binder. This will ensure that all soil material that has been machined by said chain cutter will be returned directly and slotless back into the dike body, providing an optimal rigidity.

[0024] Preferably, the soil transporting device is an auger.

[0025] A first means for applying a cloth is by means of a roll comprising a cloth, wherein the height of the cloth on said roll is substantially the same as the height of the barrier screen to be made, or the height of the chain cutter, and wherein the roll extends until the depth of the chain cutter and is embodied for being unrolled when displacing the chain cutter through the dike body.

[0026] The chain cutter is preferably built such that a roll with cloth can be unrolled in a single work pace vertically behind the chain cutter. The roll may comprise a cloth of for example bio-textile, geotextile or geomembrane (for example a foil) and is provided ready for use in a required width (said width being the height of the cloth inside the barrier screen). At the beginning and at the end of the cloth a connection means is provided such

that a subsequent cloth may be connected to said other cloth seamlessly and watertight, if necessary. Beside the connection means, a connection by means of needling, melting or gluing may be applied. Such ensures a method that is performed in a single pace and without an open slot in the dike body, also with a single device. The roll is preferably inserted into the dike at the same depth as the chain cutter so as to obtain a substantially wrinkle free unrolling. When the cloth is provided at part of the height of the dike body, the roll will be provided at the position the cloth has to be applied. So as to mutually connect the first cloth and the new cloth, the new roll is inserted into the container in which the end of the substantially unwound cloth is positioned and wherein the said cloths are mutually connected by means of a male-female connection; substantially analogous to the way sheet pilings are connected. The invention also provides a changing system wherein a new roll is brought into a container that is provided below ground level and said cloth is automatically connected to a first cloth, preferably by means of a male-female connection. To that end, the device comprises a container for a roll with a cloth, and a changer for inserting a new roll in said container when a first roll has been substantially unrolled, wherein both cloths are provided with mutually cooperating male-female connection means, said device comprising a coupling station for mutually inserting said male and female connections for connecting said cloths.

[0027] An alternative method is obtained by means of device comprising a container with a cloth, said cloth having a height that is substantially identical to the depth of the chain cutter and said device is embodied for delivering said cloth to he machined soil. Said roll is unrolled at a position above ground level. A guiding mechanism is provided for inserting the top side and bottom side of the cloth at the correct position in said machined soil. In a simple manner, said cloth may be folded after unrolling and subsequently be guided into the ground. The guiding mechanism is connected to the top side and the bottom side of said cloth, for example by means of a male-female profile, made from a sufficiently rigid edge for guiding said cloth into the ground. This embodiment allows the chain cutter to be as small as possible. As a consequence, the connection of cloth from a first with cloth from a second roll then may be done above ground level, which may be faster and without interruption of the machining method.

[0028] Both embodiments allow to provide for measuring equipment to be installed and to control said cloth or to measure any settlements and water tightness.

[0029] According to an embodiment the barrier screen comprises grains from the kind of soil that is present in the dike body adjacent the said barrier screen, said grains being mutually connected through said binder. The average grain size in said barrier screen may for example be less than one, less than two or less than ten cubic millimeter per grain. The kind of soil in said dike body adjacent said barrier screen may be homogeneous or

layered, may comprise structures that are larger than the average grain size in said barrier screen. Due to the presence of the grains in said barrier screen a much firmer structure is obtained than when feeding the binder to a layered soil of a soil comprising larger structures than the present average grain size. Grains that are built from the soil and that are connected though said binder may provide a firmer structure.

[0030] The barrier screen preferably extends until a depth within the dike body through which, without the presence of the barrier screen, soil particles would be migrated through the flow of said seepage water, for example until a depth of one to ten meters below the dike body's surface at the position of said barrier screen. An additional advantage when strengthening sea dikes by means of the present invention, is that salinization of the landbased part of the dike is prevented since the amount of seepage water can be reduced drastically.

[0031] The barrier screen is preferably embodied narrowly, having a width of between 0.1 meter and one meter perpendicularly to the longitudinal direction of the dike body, for example between 0.4-0.7 meter. In the longitudinal direction the barrier screen preferably extends continuously along the total length of the dike. In case interruptions are provided in the dike, these preferably are provided only after for example at least ten or one hundred meters of continuous barrier screen.

[0032] According to an embodiment the top position of the barrier screen is at a distance below the surface of the dike body (that is below ground level) at the position of the barrier screen, for example 0.5-2 m below said dike body's surface. According to an embodiment, the barrier screen may be covered with a top layer of clay, sand or mud. Such top layer may be used for constructing a road.

[0033] According to an embodiment the binder may be cement, bentonite, lime, topcrete or fly ash (for example certified fly ash), or a mixture thereof with another component, for example more than one chosen from cement, bentonite, lime, topcrete and fly-ash.

[0034] According to an embodiment the binder is a grout, for example obtained from a mixture of cement, water and optionally admixed with an additive and excipients, wherein said grout is mixed with said soil of said dike body for making a barrier screen.

[0035] Depending on practical considerations, it may be chosen to position the barrier screen at a water based part of the dike body (between the base of the dike and the water), or at a landbased part of the dike body (at the side of the dike that is directed away from the water) or at a middle portion of the dike body, erecting from the surroundings and substantially comprising a soil material. When the barrier screen is positioned at a water side part of the dike, use is preferably made of a substantially water tight barrier screen. Without preventing seepage water to flow through the dike body, accumulation of water and salinization of the hinterlands can be prevented.

[0036] Another embodiment comprises the step of po-

sitioning the barrier screen at the landbased part of the dike body. Such preferably comprises the application of a water-permeable barrier screen. As a consequence, at least part of the seepage water can flow through or may be absorbed by said barrier screen, whereas transport of soil particles is prevented by the presence of said screen or is at least filtered. Since the barrier screen will be embodied as a water-permeable screen any seepage water will not accumulate in the dike body with the result that a drainage system is not necessary.

[0037] Another embodiment comprises the step of placing the barrier screen at a middle ground portion of said dike body. Preferably the barrier screen is made substantially watertight in this embodiment. The embodiment in the middle portion of the dike body (the so-called crown of top) is especially preferably in case of small dikes. More in particular some peat dikes are small and usually only accessible at their top. According to an embodiment a small dike body may be embodied completely as a barrier screen as described in the present description in the case of a barrier screen forming part of a dike body.

[0038] The invention further relates to a chain cutter for making a barrier screen in a dike body for preventing transport of soil particles, said barrier screen being oriented substantially standing upright and extending in a longitudinal direction of said dike body. The barrier screen is made by mixing soil material that is present in said dike body before commencing the step of making said barrier screen mechanically with a binder. Said mixing may be performed *in situ* at a depth below the surface of said dike body.

[0039] According to an embodiment of the invention the soil material that is already present in said dike body before commencing the step of making the barrier screen is converted in grains, for example by means of grinding, milling and/or cutting, and said grains are mutually connected by means of mixing same with said binder. Said mixing can be performed simultaneously with the step of making said grains.

[0040] Preferably, the soil (i.e. the dike body material) is machined such that grains (also comprising grain-like particles) are obtained with an average volume of less than ten, especially less than 1 or 2, cubic millimeter per grain. The size distribution of grains is preferably substantially homogeneous. By machining the soil of the dike body until grains are obtained and binding same with a binder, the barrier screen becomes sufficiently firm. In case of peat material, this has the additional advantage that the layered structure of said peat has disappeared *in situ*.

[0041] According to an embodiment the binder is added as a powder from a binder container to the soil. The dike material's intrinsic humidity enables one to mutually bind the grains by adding dry powdered binder.

[0042] According to an embodiment the binder comprises cement, bentonite, lime, topcrete or fly-ash, or a combination thereof. According to another embodiment,

the binder is a grout, for example as obtained from a mixture of cement that has been moistened with water and optionally added aggregates and additives wherein grout is mixed with the soil material so as to yield a barrier screen. In addition to that, the binder may be a liquid. This has the advantage that the binder may be added to a non-humid soil material for making a barrier screen; such (semi)liquid binder can be pumped relatively easy from a binder container.

[0043] According to an embodiment the binder is added from a predetermined depth and lower into the soil, for example by applying a supply device. This allows one to save space above said barrier screen for constructions like roads and gates. As a matter of fact, the barrier screen will have such consistency as to be cuttable with an excavator. No concrete wall is made in the dike's body.

[0044] According to an embodiment the barrier screen is made by means of a cutter, as a chain cutter, that is provided with moving chisels for cutting the soil material, according to which method said cutter is moved substantially continuously through the dike body's soil material so as to mill and cut the said soil along the trajectory of the barrier screen to be made, and wherein the binder is injected into the soil through which the chisels are moved. As a consequence, any preliminary removal of soil material is not required. The binder is added together with the step of cutting and remains mixed with the machined soil at the positions the cutter has performed its cutting actions and subsequently has been removed from. By such local cutting action, a homogeneous grain structure is obtained that is less diverse than when injecting a suspension or when pressing a binder into said soil as such. The chain cutter may provide a simultaneous step of a mechanical mixing of binder and said cut and milled soil.

[0045] Hence, the barrier screen's shape and position is determined by the movement of the cutter.

[0046] The chisels may provide a cutting and/or mixing action and are provided for cutting soil material and mechanically mixing the binder and said machined soil material.

[0047] By applying a 3D-positioning system the cutter may be positioned such for making each of the columns of the barrier screen.

[0048] According to another embodiment, the barrier screen is made from one piece along the dike body. The cutter may comprise a chain cutter that is displaced, or transported, substantially horizontally and along the trajectory of the barrier screen to be made, wherein the chain cutter extends to a depth of the lowermost part of the barrier screen to be made. As a consequence, a homogeneous barrier screen may be made.

[0049] According to another embodiment, a cloth is unrolled behind the chain cutter when making the barrier screen such that said cloth remains incorporated in the mixture of soil material and binder that was obtained in the method. The cloth may extend in the longitudinal direction of the dike body and may be incorporated in the center of said barrier screen. Said cloth is an additional

barrier against flow of seepage water and soil particles although the cloth in itself may be water permeable. Said cloth may in itself be a barrier but it may be not sufficient for practical reasons. For example, said cloth may be more vulnerable to damage leading to spaces through which soil particles may be transported together with said seepage water and it may be less resistant to pressure. For that reason, it is advisable to provide said cloth in combination with a barrier screen obtained by mixing soil particles with a binder.

[0050] The barrier screen may be water tight or (semi) liquid permeable. Such can be controlled by setting the amount of binder that is added per unit volume of soil, and the kind of binder. The required amounts and the kind of binder may be determined experimentally. Prior to placing the barrier screen a first step may comprise the step of determining the required permeability of said barrier screen. By taking a sample of said dike body's soil material, or a comparable soil material, it may be determined experimentally if, after having added different amounts of binder, the required permeability has been obtained. In case of standard types of soil material, the results may be entered into (and retrieved from) a table, such that a choice of a required amount of binder can be determined without the need of performing further experiments.

[0051] For example, in case the soil is a clay, peat or a soil without bearing capacity, said mixture may comprise 100 kg binder per m³ soil, for obtaining a substantially watertight barrier screen. According to an embodiment, at least 90 % of the amount of seepage water is restricted compared to a dike body without a barrier screen. For example, in cases where the mixture comprises 60 kg binder per m³ soil, the barrier screen may have a porous structure, comparable to clay and comprising small pores. These pores are relatively small compared to for example the width of a barrier screen column, with the consequence that part of the seepage water may still flow through the barrier screen, but wherein transport of soil particles is prevented. Preferably, the barrier screen has a permeability of between 0-0 -- 10⁻⁹ m/s, according to Darcy's law, but this permeability may be altered, depending on the circumstances. Furthermore, since the barrier screen has a clay like structure, the screen may be flexible. As a consequence, the screen may move with the soil without tearing.

[0052] The invention further relates to a device for making a barrier screen in a dike, provided with a chain cutter comprising ground cutting chisels, a binder container, and a supply device embodied for feeding binder from said binder container to a position near the chisels during milling and cutting.

[0053] It is mentioned that the technical measures relating to the dike also may be implemented advantageously as such as well in dike bodies comprising different configurations, i.e. the individual measures may be de isolated from the context used above and may be applied as such, optionally applying one or more meas-

ures mentioned above.

[0054] These and other aims and favorable aspects become clear from the description of examples and figures to follow.

Fig. 1 shows a schematic view of a dike without a barrier screen;

Fig. 2a-c shows schematic views of a dike body according to Fig. 1 comprising a barrier screen according to the invention;

Fig. 3 shows a top view of the barrier screen according to Fig. 2 wherein overlapping columns are shown; Fig. 4 shows a schematic view of a method for placing a barrier screen in a dike body for preventing transport of soil particles;

Fig. 5 shows a schematic view of a machine cutter that can be used in the method according to Fig. 4;

Fig. 6 is an embodiment of the chain cutter as exemplary device in the method according to Fig. 4;

Fig. 7 is a top view of a cloth device for use with the chain cutter of Fig. 6.

[0055] It is mentioned that the figures depict schematic views of preferred embodiments of the present invention, being provided as non-limiting examples. In the figures, the same or corresponding parts are denoted by the same reference numbers.

[0056] In Fig. 1 a dike 1 is schematically shown and which comprises a longitudinal dike body 4 that separates landbased part 2 and a water area 3. Said dike body comprises at a first side of said water area 3 an outer dike part 5, at the landbased part it comprises an inner dike part 6 and in between said outer dike part 5 and said inner dike part 6 it comprises a middle portion 7. Said middle portion has a top 8 that embodies the crown 9 of the dike 1. Said crown 9 prevents water flowing from the water area to said landbased area. In Fig. 1 tunnel shaped spaces 10 are shown in dashed lines that may be obtained due to a water level difference between said water area and said landbased area. Through these tunnels 10 seepage water 33 migrates together with soil particles 34. Said soil particles 34 are grain like soil particles that are carried along by said seepage water and may differ in size between about 1 micrometer and 4 millimeter.

[0057] In Fig. 2a-c a dike body is shown schematically comprising substantially erect barrier screen 11 made from soil of said dike body mixed with binder. The soil may have the shape a homogeneous structure of particles that are bound by said binder, said particles being comprised of about the same material composition as the dike body (the term particles also refers to grain like parts). The particles are mutually bound with a binder. The mixture of the dike body's material and binder may have a clay like structure, even if the grains themselves are comprised of peat and the dike itself comprises peat.

[0058] The barrier screen may be provided in the inner dike part 6, the outer dike part 5 or the middle portion 7.

It is also possible that a plurality of barrier screens are provided in the dike body, in the same or different parts of the dike body. The barrier screen serves as a means for preventing transport of soil particles. To that end the barrier may in itself hinder the flow of seepage water, or may at least partly hinder the transport of the soil particles that are transported by the flow of seepage water, even in cases where the flow of seepage water itself is not substantially hindered. Preferably, the barrier screen extends until a depth in the dike body 4 where seepage water 33 flows together with particles 34, for example a depth between about 4 meter and about 10 meter.

[0059] According to an embodiment wherein the barrier screen 11 is positioned in an outer dike part 5 (Fig. 2a) it may be substantially water tight, which means that less seepage water is carried along the dike body than is required for keeping the dike saturated with water. For example, the barrier screen 11 only allows maximally about 10 % of the flow of seepage water, through the barrier screen, compared to the situation without a barrier screen 11.

[0060] According to an embodiment wherein the barrier screen 11 is positioned in the crown of the dike (Fig. 2b) this may be made substantially water permeable. Optionally, the complete crown may be part of the barrier screen, especially in case of a small dike.

[0061] According to an embodiment wherein the barrier screen 11 is positioned in the inner dike part 6 (Fig. 2c) it may be embodied substantially water permeable, which means that at least as much seepage water is allowed to permeate as required for preventing seepage water to accumulate between the crown of the dike and the barrier screen 11. Such is obtained with a barrier screen 11 that comprises pores that have a diameter such that at least part of the seepage water flows through said pores and wherein the particles that are entrained with said seepage water are retained by said barrier screen. For example, the barrier screen 11 retains 1-20 % of the seepage water, compared to a case where no barrier screen 11 is provided.

[0062] Fig. 3 schematically shows a top view of an alternative embodiment of the barrier screen 11 being made of a concatenation of columns 12. Said columns may be positioned close to each other but preferably the columns have an overlapping portion 13 wherein the columns 12 partly overlap, as shown in the Figure. This ensures a continuous barrier screen as in the method according to the invention. The effects and advantages of a barrier screen made from a series of columns is analogously applicable to a barrier screen obtained with a chain cutter. The length of a single column 11 in the longitudinal direction of the barrier screen 11 is for example between 1 and 4 meter, and preferably about 1.5 meter. The height of the column 12 is between 2 and 10 meter and is preferably about 7 meter. The thickness of a single column is between 0.1 and 1 meter and is preferably about 0.6 meter. By embodying the barrier screen from overlapping columns in the longitudinal direction of the

dike body the barrier screen may extend along the dike body without any interstitial spaces interrupting the barrier screen. The columns may be positioned substantially erect, meaning that the longitudinal direction may be about vertical, herein also identified as standing columns.

[0063] According to an embodiment the barrier screen extends in a height direction that does not higher than a distance below the dike's surface level 14. A top 31 of said barrier screen 11 may be positioned below the surface of the dike body, for example 0.5 - 2 m below said surface.

[0064] The binder that is used for being mixed with the soil material of said dike body for making the barrier screen column is preferably chosen from a cement, bentonite, lime, topcrete or fly ash (topcrete is a by-product from the paper industry and that may be used as a binder).

[0065] The invention further relates to a method for making a barrier screen 11 in a dike body 4 for preventing transport of soil particles. The barrier screen 11 is made by in situ mixing of soil of said dike body 4 mechanically with binder at the position where the barrier screen is to be made. To that end, soil is milled substantially at the same time of mixing same, with the consequence that the soil is converted into grain like particles with a substantially homogeneous particle size distribution.

[0066] The binder connects the grain like particles so as to obtain a rigid structure making the barrier screen.

[0067] In the embodiment according to Fig. 4 substantially standing columns are made in the soil by means of an alternative device by mechanically mixing binder 15 from a container 12 with the soil, by using a cutter 17. Preferably, an open slit above the cutter's head is not necessary. The binder 15 may be provided as a powder like cement, and since the soil material in a dike body is at least partly moist, this will ensure a proper mixing between the binder 15 and the soil. The binder is fed by a supply device 21 that is provided on the cutter 17. For example, it may be fed to the soil from a predetermined depth below the top surface of the dike body 4, like between 0.1 and 10 meter below the top surface of the dike body 4.

[0068] By said mixing a somewhat raised surface may be obtained at the position of the barrier screen 11. According to an embodiment the soil is pressed, for example by driving a heavy machine over said raised surface or by positioning a weight on it. Said pressing increases the rigidity of the barrier screen 11.

[0069] The barrier screen 11 may be water tight or liquid permeable. For example, when the soil of said dike body 4 comprises clay-like, peat-like or no load-bearing surface it may be mixed with 100 kg per m³ binder so as to obtain a substantially water tight barrier screen 11 such that about at least 90% of flowing seepage water is retained by said barrier screen 11, comprised with a situation without a barrier screen 11. If in such case for example 60 kg per m³ binder is added to the soil material of said dike body a substantially water permeable barrier

screen 11 may be obtained. The liquid permeability of said barrier screen 11 may for example be between about 0-0 -- 10-9 m/s according to Darcy's law, such that migration of soil particles through the dike body 4 from the water area to the landbased part 2 due to the seepage water is hindered effectively.

[0070] In Fig. 5 a schematic view of a cutter 17 is shown, being used in a device for making in a dike body a barrier screen 11 that is made of a series of columns. The cutter 17 comprises a cross shaped body 18 provided with a standing part 19 and a lying part 20 being positioned substantially perpendicular with respect to each other. The standing part 19 is provided with a supply device 21 through which binder 15 may be transported from the container 16 to the end 22 that debouches near said lying part 20 for injecting the binder 15 in the soil for making the barrier screen column 12. The directions of injection shown by means of arrows.

[0071] At the side of said lying part 20, rotating cylinders 25 comprising soil cutting chisels 26 are provided. When in use, said laying part 20 is positioned substantially along the dike body 4. The chisels 26 serve as cutters and mixers for cutting the soil and mechanically mixing the binder 15 that is injected with the cut soil so as to obtain a barrier screen column 12. As shown in this Figure the end part 22 of the supply device 21 ejects the binder from a central part of the standing part towards the soil cutting chisels 26. According to an embodiment additional mixing paddles may be provided on the cylinder that do not provide for a cutting of the soil.

[0072] The cylinders 25 are guided vertically through the cut soil in a horizontal position.

[0073] At the end of the standing part 19 rotating cutter head 23 is provided. For illustration purposes, in the figure the cutter head is detached from the figure, But in practice the cutter head is at a lowermost position longitudinally with respect to the standing part 19. When in use, the cutter head 23 makes its way downwardly between the cylinders 25 of said cutter 17, for example vertically downward, through the dike body's 4 soil. To that end, the cutter head 23 is provided with moving chisels 24 for cutting and milling the soil.

[0074] Since the cutter 17 is provided with rotating cylinders 25 comprising cutting and mixing chisels 26 the making of large clumps of soil that do not contain any amount of binder is prevented. Such clumps would deteriorate the barrier screen's strength. The risk of such clumps would exist if the binder would only be injected into the soil and the soil would not be converted into grains and be mixed, for example by means of said mixing chisels.

[0075] Positioning the cutter 17 is preferably obtained by means of a 3D positioning system, for example by applying GPS positioning.

[0076] An embodiment of the device according to the invention for making a barrier screen 11 in a dike body is schematically shown in Fig. 6. In this Figure, the cutter 17 comprises a chain cutter 27. Said chain cutter 17 is

provided with continuously rotating transport chains to which cutting and milling chisels are connected. When in use, the chain cutter 17 extends to a depth, until the lowermost portion of the barrier screen 11. Preferably, the depth applied is lower than the depth at which detrimental seepage water flows, for example at a depth of between 2 meter and about 10 meter and preferably until a depth of about 7 meter.

[0077] When in use, the chain comprising the chisels is moved vertically, such that soil material will become cut loose. A supply device 21 will feed binder for example at a position that the cut soil material arises above surface level and optionally also at one or more depths, for example at the downward directed portion of the chain 27. The chisels provide for mixing of the soil material and the binder 15. Furthermore, the chain cutter 27 is displaced substantially horizontally along the dike body 4. This has the advantage that a barrier screen 11 is made that is substantially continuous in the longitudinal direction and that is not made of a plurality of separate columns 12. The chain cutter 27 spills soil material that has been machined to grain like articles on the dike body's surface.

[0078] According to another embodiment the dice comprises an auger. Said auger serves for returning oil material that has been spilled on the dike back into the dike body. In the device the auger may be provided at surface level and behind the chain cutter seen in horizontal displacement direction). The rotation axis of said auger may be perpendicular to the displacement direction (or transport direction) of said chain cutter (for example, perpendicular thereto or obliquely backwards. Instead of the ager, other soil displacing devices may be applied.

[0079] Fig. 7 shows another embodiment wherein besides the chain cutter 27 a cloth device is provided. As shown in Fig. 7, said cloth device 28 comprises a cylinder 29, or roll 29, around which a cloth has been rolled. Said roll 29 has a length that is substantially the same as the height of the chain cutter 17 and is positioned along said chain cutter 17. When horizontally displacing said chain cutter through the soil material, the roll is moved along behind said cutter. Said cloth 30 may be root cloth. When the soil material is machined and mixed, part of said cloth is incorporated into said barrier screen 11 to be made, upon displacement of said chain cutter. Said cloth unrolls automatically since the end (actually the starting point of said cloth) pinpoints itself in said barrier screen. As a consequence, the cloth 30 is unrolled when displacing said roll 29. Aid roll 29 may be replaced by another roll when in use. Upon replacement said roll 29, the end of said previous cloth 30 is connected and new cloth 30 mutually connected, mechanically with some overlap. Said cloth 30 is preferably unrolled in the center of said barrier screen. According to an embodiment a plurality of rolls 29 may be unrolled simultaneously and in parallel. Such can be done for ensuring reliability.

[0080] In Fig. 7 an auger 35 has been depicted schematically (the driving mechanism of said auger 35 has

been omitted from the drawing). The auger 35 is positioned behind the chain cutter 27 (as seen in a horizontal transport direction) and perpendicular to the chain cutter's 27 transport direction. The auger 35 serves for returning any soil material that has been spilled on the dike body's surface back into the dike body.

[0081] The invention also relates to a device 32 according to Fig. 4 for making a barrier screen 11 in a dike 1, comprising a cutter 17 that is provided with soil cutting and milling chisels 24, 26, a binder container 16, and a supply device 21 that is embodied for feeding binder 15 from the binder container 16 during said milling and cutting operation to the chisels 24, 26.

[0082] The method and device are described for improving dikes, wherein a longitudinal barrier screen 11 is made in the soil for preventing the transport of soil particles. A comparative method and device may be used for other aims as well, for example for mixing a block of soil with a binder, wherein such block of soil may be much thicker than a barrier screen. Such block may for example be used as a foundation for building purposes. Also, the method may be used for immobilizing or fixating contaminating particles in the ground. To that end, the columns may be made in two horizontal continuous directions, for example in the shape of a rectangle or another shape of a closed area as seen from above. Also, the method may be made in a series of parallel, preferably partially overlapping, lanes by means of the chain cutter. In that case a rigid block of soil is obtained, wherein said block is obtained by mixing soil already present *in situ* mechanically below surface level with a binder.

[0083] For obtaining a wide barrier screen 11 a plurality of lanes or rows of columns may be required.

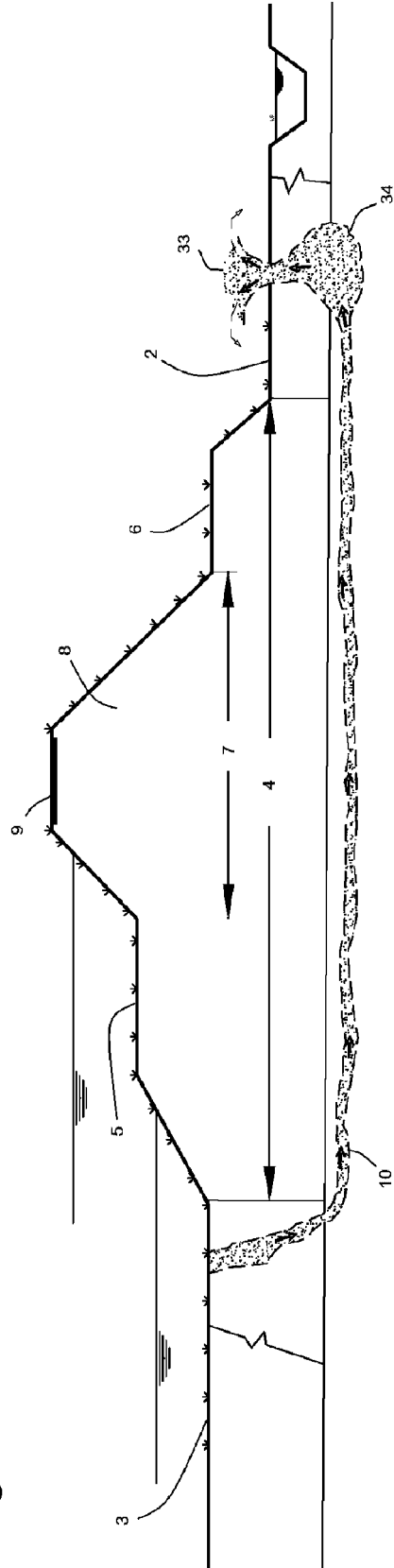
[0084] It will be clear to a man skilled in the art that the invention is not limited to the embodiments as described above and as depicted in the drawing. Many embodiments are possible within the scope of protection conferred by the appending claims.

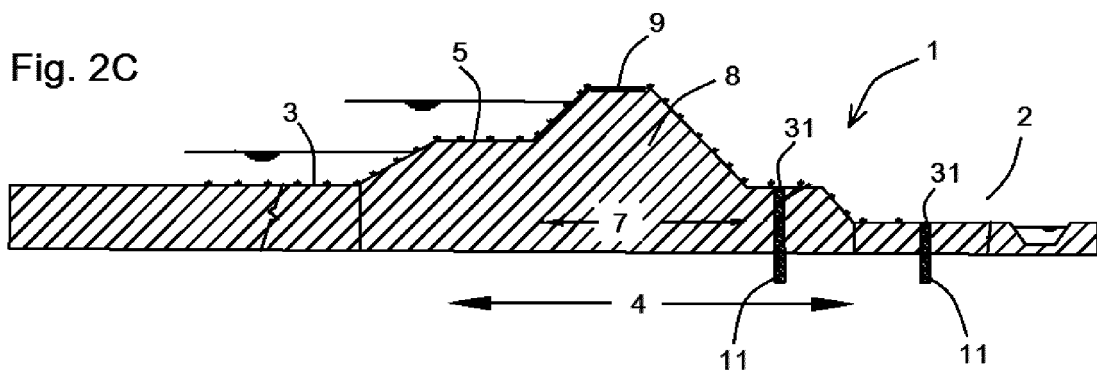
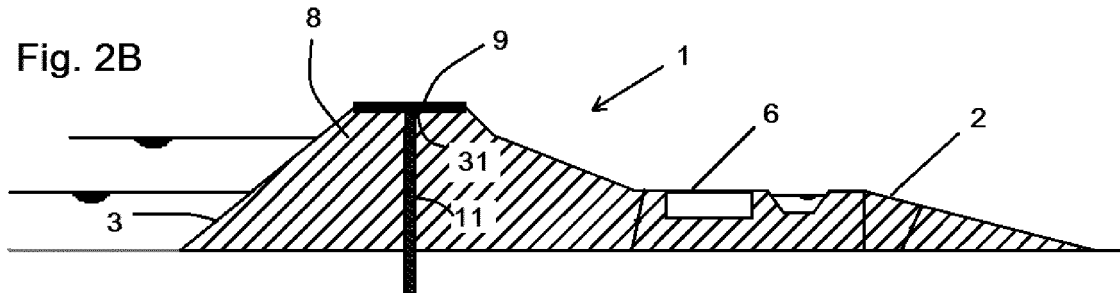
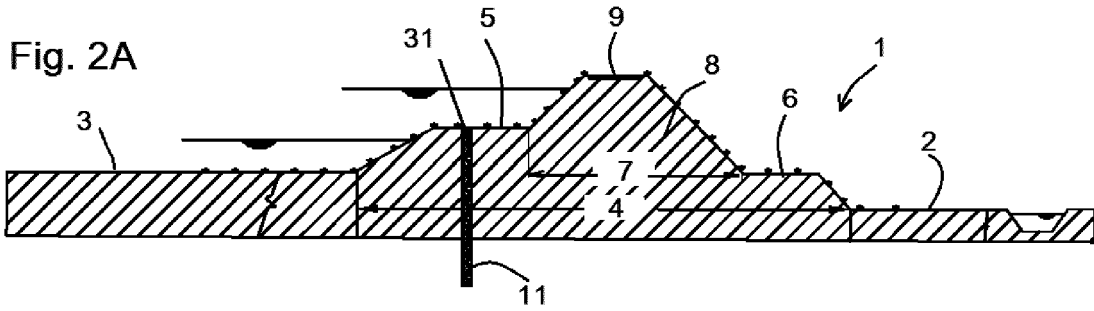
Claims

1. A method for making a barrier screen in a dike body for preventing transport of soil particles, said barrier screen being positioned substantially standing and extending in a longitudinal direction of said dike body, wherein in said method said barrier screen is obtained by mechanically mixing soil that is already present in said dike body with a binder, **characterized in that** the method comprises the step of displacing the chain cutter along the trajectory of the barrier screen to be made through the dike body and mixing the soil present and the binder as well as inserting a cloth into the mixed soil.
2. A method according to claim 1, wherein said cloth is provided at substantially the height of the mixed soil.

3. A method according to claim 1, wherein said cloth is positioned behind the chain cutter into the mixed soil.
4. A method according to claim 1, wherein said cloth has a porosity with a permeability for at least partially passing water. 5
5. A method according to claim 1, wherein the chain cutter is displaced substantially horizontally through said dike body (4) for making a longitudinal barrier screen in said dike body. 10
6. A method according to claim 3, wherein said cloth is positioned in the middle part of said mixed soil. 15
7. A device for making a barrier screen (11) in a dike body (1), provided with a cutter (27) comprising soil cutting and milling chisels (26), a binder container (16), and a feeding supply (21) for, upon said cutting method, feeding binder (15) from said binder container (16) to the chisels (24, 26), wherein said cutter (27) comprises a chain cutter (27) for cutting and milling soil material and mixing same with a binder (15), said device further being embodied for inserting a cloth in said mixture of cut and milled soil material and binder. 20
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8. A device according to claim 7, further comprising a soil transporting device (35) for inserting any soil material that is spilled on the dike's surface by the chain cutter into the dike body (27), said spilled material optionally being mixed with binder (15). 30
9. A device according to claim 8, said soil transporting device (35) being an auger (35). 35
10. A device according to claim 7, said device comprising a cylinder (29) with a cloth material (30), said cylinder (29) extending until the depth of said chain cutter (27) and being embodied for being unrolled when displacing the chain cutter (27). 40
11. A device according to claim 7, said device comprising a container with cloth, said container being positioned above ground level and being embodied for depositing said cloth to the mixed soil when displacing the chain cutter (27). 45
12. A device according to claim 10, said device comprising a holder for the cylinder (29) with cloth (30), and a changing device for inserting into the holder a new cylinder (29) with a cloth when another cylinder (29) has been unrolled substantially completely, wherein both cloths are provided with mutually cooperating male-female connections, said device comprising a coupling system for inserting said male and female connections for mutually connecting said cloths. 50
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Fig. 1





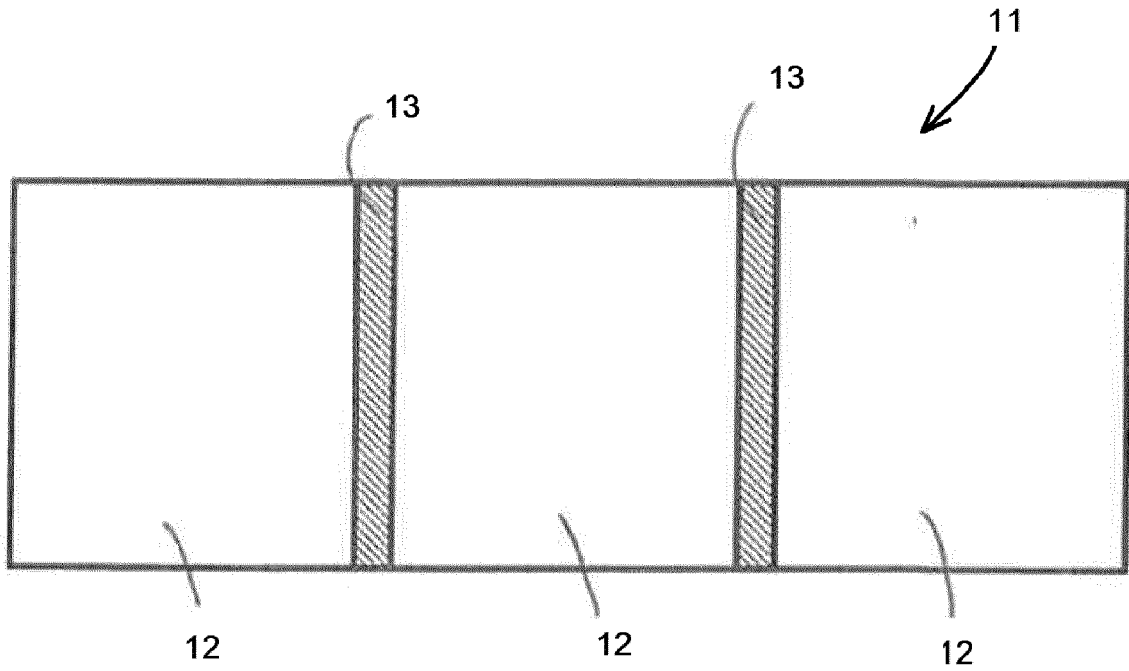


Fig. 3

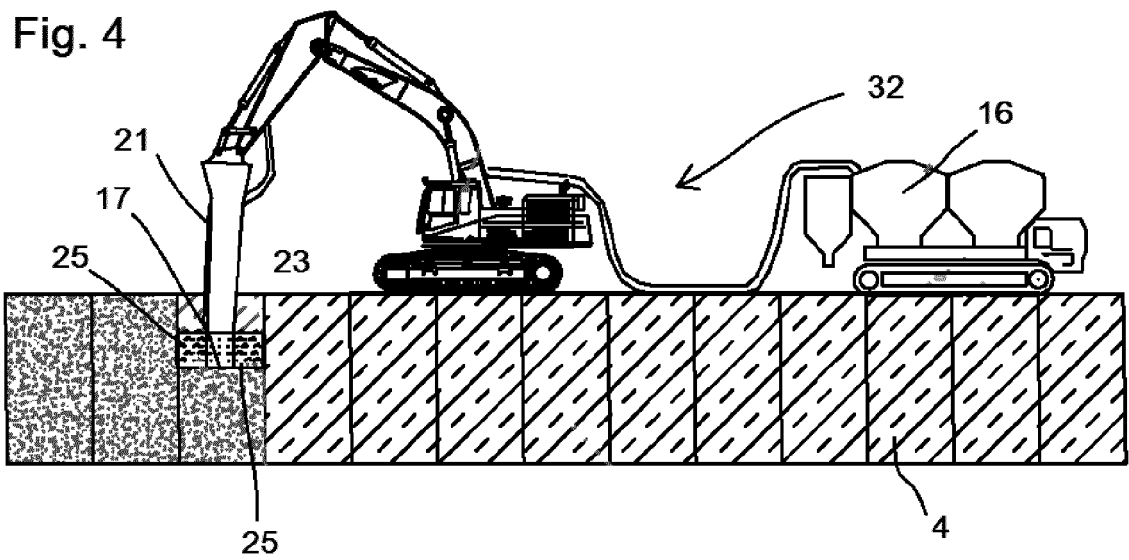


Fig. 4

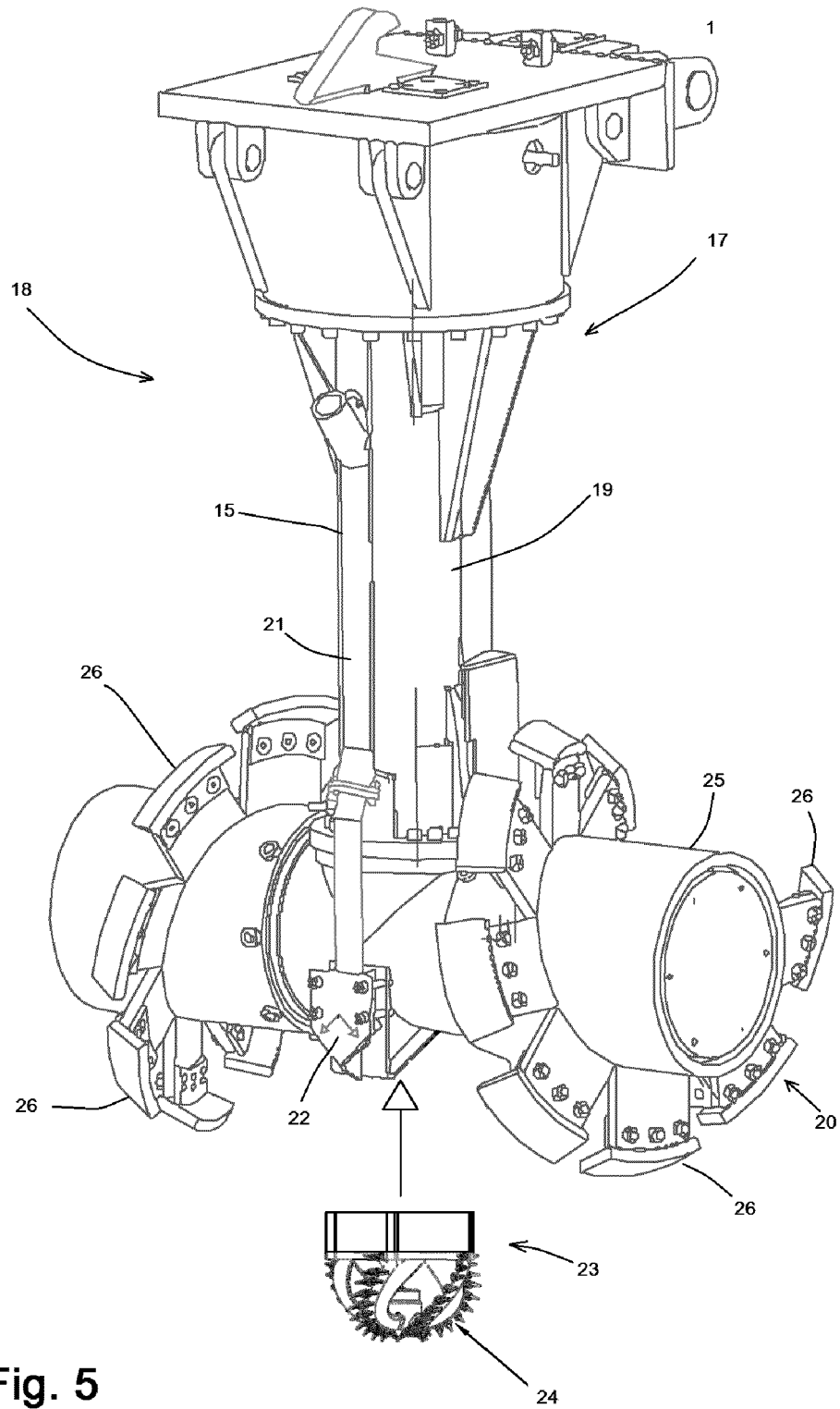
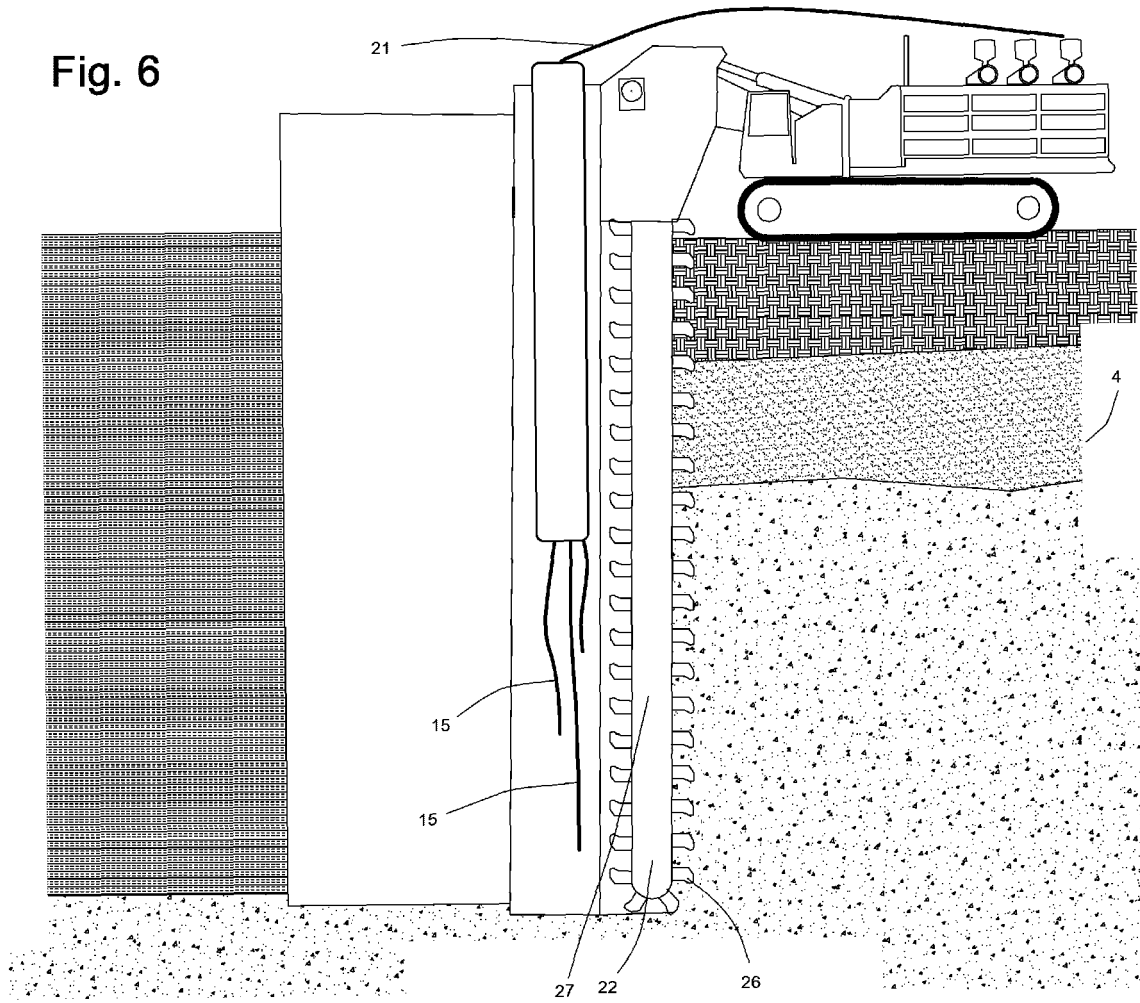
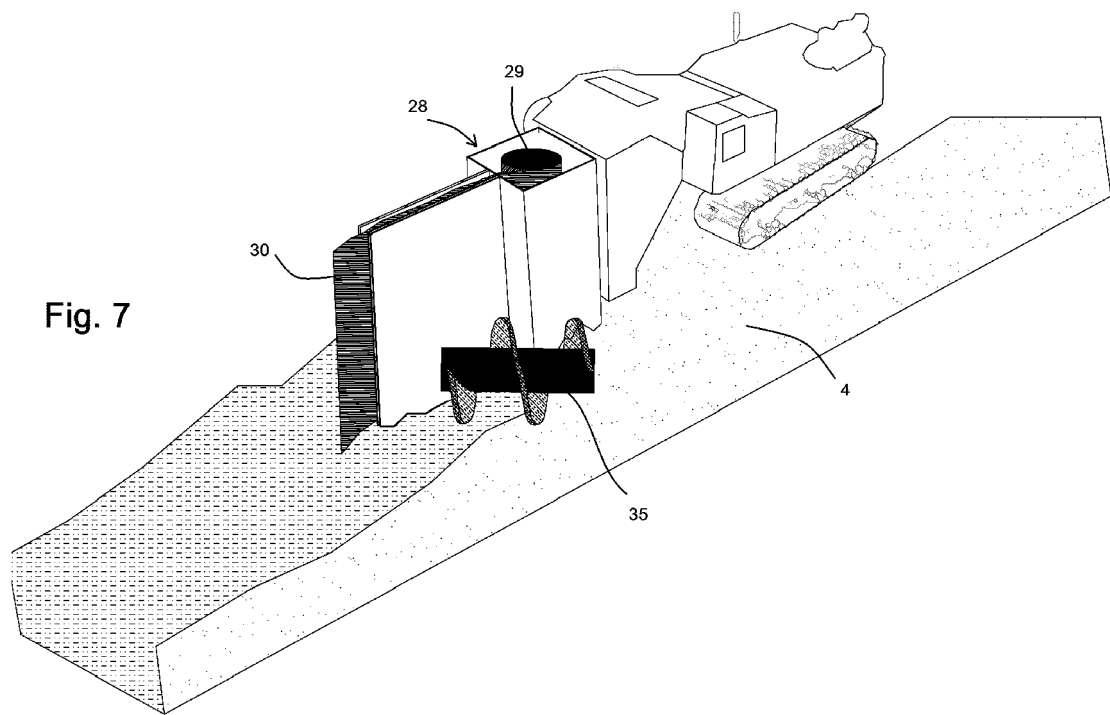


Fig. 5

Fig. 6







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Application Number
EP 15 18 1185

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Place of search The Hague		Date of completion of the search 15 December 2015	Examiner Leroux, Corentine
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