



EUROPEAN PATENT APPLICATION

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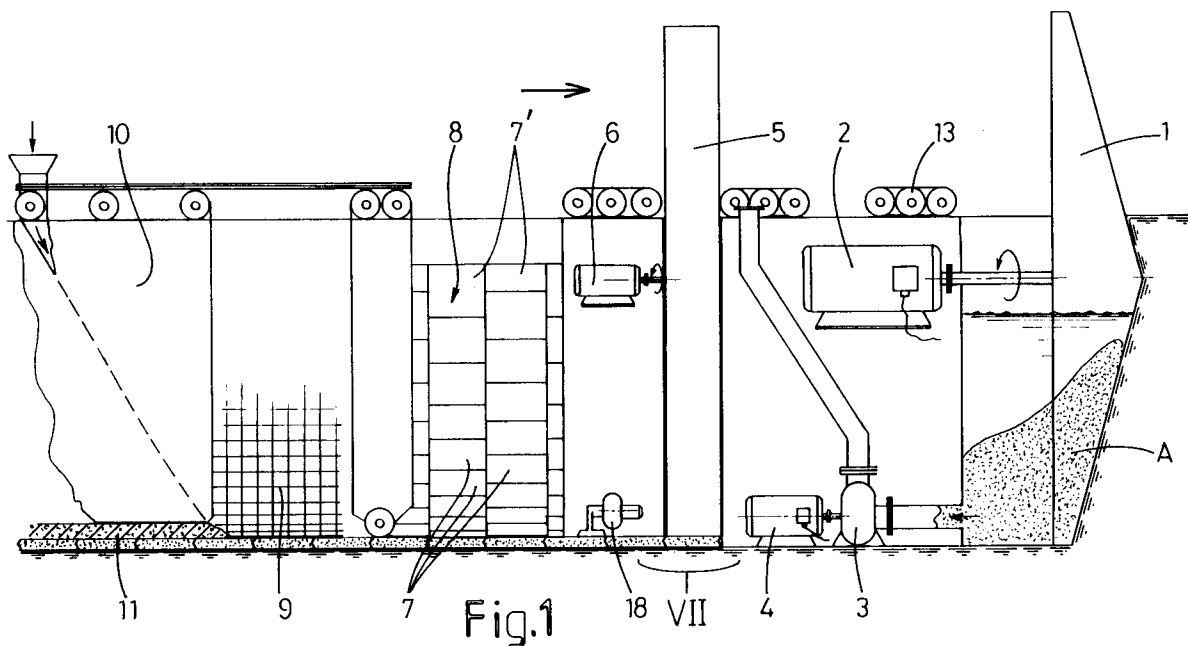
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54 Method and apparatus for making a lined trench in the soil; as well as a lined trench.

(57) In a method of making a lined trench in the ground, a trench is dug into the ground, and, immediately after that, shells are placed consecutively and in sealed adjoining relation in the trench, and are anchored by anchoring elements. The shells are composed of engaging shell elements, around which a prestressing element is provided, the shells being

supported at the upper ends by the anchoring elements. The invention further comprises the lining produced according to this method, as well as an apparatus for implementing the method, which comprises a leading digging machine and a trailing shell-mounting device.



FIELD OF THE INVENTION

The present invention concerns a method and an apparatus for making a lined trench in the ground; as well as such a lined trench.

For the construction of roads, railways etc. in areas with a high groundwater level, a deepened construction thereof in the traditional way is complex and expensive. Often drastic and long-lasting drainage by well points has to be executed at the cost of the surrounding soil.

SUMMARY OF THE INVENTION

The present invention now aims to provide a method enabling a fast and continuous construction of a lined trench which does not require drainage by well points.

To this end, the method according to the invention is characterized in that, first of all, a trench is dug into the ground and that, immediately after that, shells are placed consecutively and in sealed adjoining relation in the trench, being supported and anchored by anchoring elements.

As a result of these measures, the groundwater level does not have to be lowered. On the contrary, the upward pressure exerted on the trench lining by the surrounding ground and any groundwater present therein, can be made useful, said lining preferably having a semicircular shape in order to advantageously convert all ground forces exerted thereon primarily into pressure forces in the circular walls of the trench lining.

The shells are preferably composed of engaging shell segments, around which or inside which a prestressing element is provided, said shells being supported and anchored by the anchoring elements at the upper ends thereof.

Thanks to this embodiment, the shell elements can be easily prefabricated and transferred to the work concerned, where they are linked to each other by a slightly "pivoting" joint and are held under pressure tension, and thus in place, by the prestressing elements. The said prestressing elements may consist of prestressing cables which pass through aligned cavities in the shell elements and are given a certain tension at the ends thereof. Individual sealing elements between or around the shell elements provide the sealing of the trench lining. It is also possible to combine these prestressing elements and seals to a watertight membrane which is placed around the shell elements under prestressing tension during the mounting of the shell elements.

It is favourable to combine the shell elements to a semicircular shell and to place straight elements between the semicircular shell and the anchoring elements. The anchoring elements can be

formed by girders or head beams placed on piles on both sides of the trench to be formed, which girders are positioned prior to digging the trench to guide the apparatus for implementing the method.

In this way, a very advantageous embodiment is realized, both with respect to the absorption of forces and with respect to the simplicity of mounting. The girder or head beam placed on foundation piles has various functions. First of all, it serves as a support and guide for the digging machine, simultaneously being able to absorb the reaction forces of the forward drive. Secondly, the pressure and/or tensile forces on the concrete shell elements and the prestressing elements are diverted, the tensile force on the prestressing element being adjustable, for example, via a tensioning nut by means of a threaded rod extending through the head beam. Thirdly, the head beam has to transfer the possible vertical resultant of the upward force to the surrounding ground via the foundation piles. A fourth function of the embodiment is that it can serve as a foundation for possible noise-protection walls, masts for overhead wires and even for lightweight footbridges over the road or railway passing under these. It is also possible to support the head beams only by means of a vertical pile and to fasten parallel head beams to each other by means of a cross connection.

For the purpose of digging the trench, a continuous digging machine is used. A rotating digging arm at the front of this machine continuously digs out the ground in front of the machine and removes this via an apparatus which is provided on the digging machine. Under normal circumstances, this machine will be provided with the traditional "cutter head" as used in dredging, in which a rotating head with water jets squirts the ground away and digs. This ground is then pumped away to a dumping site by means of a dredging pump. A "dry" digging method is also possible.

The digging machine is provided with a shell-mounting device immediately behind the digging part, which also contains the drive for the digging head, dredging pump and motor. The shell-mounting device may comprise, in one embodiment, a mounting wheel, onto which the shell elements can be fed in order to position the shell elements, by rotation, in the right place in the trench. This independently rotating, entirely circular mounting wheel has a smaller diameter than the circular body or shield of the first part of the digging machine, in order to allow the shell elements to be moved between the mounting wheel and the shield when they are positioned in the trench. The shell elements are disposed in the circumferential rim of the mounting wheel by an automatic stacking apparatus, the orientation of disposition being such that the shell elements automatically slide, by their

own weight, into the right position. In the case of sealing by means of a membrane, the membrane is simultaneously tensioned across the shell element, linking up with the previously placed membrane via a groove joint. As soon as this position is reached, the forward displacement of the digging machine will be interrupted, allowing the coupling of the membranes and the positioning of the concrete shell elements to take place. One half of the wheel may be provided with a progressively increasing diameter, in order to push the ground and groundwater aside. The shield may extend as far as, under and even slightly beyond the mounting wheel.

In order to prevent piping erosion via the joints of the shell elements, these have to link up accurately and show dimensional stability. The small amount of water liberated during the forward movement of the machine can simply be sucked away by means of a vacuum pump in the rear part of the digging machine. It is also possible to provide a seal with a single or multiple trailing autosealing elastomer lip close to the rear end of the lower shield of the apparatus which has the shape of a circle segment, in which case the sealing pressure is directly derived from the hydrostatic pressure on the outer side of the shield.

In an alternative embodiment, the shell segments are combined to a shell and moved to the right level, in order to be connected to a preceding shell. To this end, the shell-mounting device of the apparatus may comprise a mould for constructing a shell from shell elements, which mould is adjustable in height and preferably consists of a segmented inflatable pillow. The trench lining thus placed can be provided with a continuously applied inner lining, for example of reinforced concrete.

SHORT DESCRIPTION OF THE DRAWINGS

The invention will hereinafter be further illustrated with reference to the drawings, which illustrate embodiments of the invention.

Fig. 1 is a very schematic longitudinal section of the embodiment of the invention for making a lined trench in the ground.

Fig. 2 is a transverse section of the open excavation which remains after the passage of the digging machine and the mounting wheel for the shell elements.

Fig. 3 is a partial section on a larger scale according to the line III-III in Fig. 2.

Fig. 4 shows detail IV of Fig. 2 on a larger scale.

Fig. 5 shows detail V of Fig. 2 on a larger scale.

Fig. 6 is a transverse section of the lined trench used as a deepened railway.

Fig. 7 is the detail VII of Fig. 1 of an alternative embodiment of the shell-mounting device of the apparatus according to the invention, represented on a larger scale.

Fig. 8 shows in a very schematic perspective partial view of the apparatus of Fig. 7 the principal of the shell-mounting device.

Fig. 9 is a section of an alternative embodiment of the trench lining according to the invention, corresponding to Fig. 5.

Fig. 10 is a view according to the arrow X in Fig. 9.

Fig. 11 is a perspective view according to the arrow XI in Fig. 10.

Fig. 12 is a section according to the line XII-XII in Fig. 10, represented on a larger scale.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 of the drawings shows that the apparatus for making a lined trench in the ground comprises a digging wheel 1 in the form of a cutter-suction dredge. The digging wheel 1 is driven by a motor 2. The detached ground A is removed together with water by a dredging pump 3 which is driven by the motor 4. Behind the digging part of the apparatus, a mounting wheel is provided, which is preferably adjustable in upward and longitudinal direction, and which is driven by a motor 6. By means of this mounting wheel 5, the axis of which is parallel to the longitudinal direction of the apparatus, each shell 8 composed of separate shell elements 7 is moved by rotation into the trench. Any leak water is removed by a vacuum pump 18.

Subsequently reinforcement steel can be placed in the resulting open excavation, and then a concrete lining 11 can be cast by means of a sliding falsework 10.

Fig. 2 shows in a transverse section the open excavation after digging the trench and applying the shells 8 consisting of shell segments 7. It can be seen that the shells are supported at the ends in upward direction via the straight shell elements 7' by horizontally extending concrete head beams 12 which also have the function to support the wheels 13 of the apparatus for making a lined trench in the ground. The head beams 12 are anchored to the ground by foundation piles 14 provided at regular intervals. Figs. 2 to 5 show that a membrane 15 has been tensioned around each shell. The tension of the membranes 15 is maintained by tensioning pins 16 which are guided through the head beams 12, as can be seen in detail in Fig. 5. The membranes 15 have been installed by means of the mounting wheel 5. Adjacent membranes are interconnected in an auto-sealing fashion and are resistant to tensile strain by a groove joint 17. Fig. 6 shows the final lined

trench, in which a two-track railway has been constructed in a deepened fashion.

Figs. 7 and 8 show an alternative method of combining the shell elements 7 to the shell 8. In this alternative method, the shell elements 7 are moved, by means not shown, to the right places in the shell on a hydraulic or pneumatic pillow 17 which is part of a shell-mounting device provided close to the rear end of an at least semicircular lower shield 18 of the apparatus. The pillow 17 can be inflated with a gas, such as air, or with a liquid, and preferably the pillow 17 is divided circumferentially into sections or segments, so that the height of the supported shell 8 can be locally adjusted, in order to align the shell elements 7 with the shell elements 7 of a preceding shell.

Fig. 7 further shows that the shield 18 is provided at the rear end with a seal with two elastomer sealing lips 19, 20 which are held in sealing engagement with the lower side of the shell 8 which has already been placed by the pressure of the ground and groundwater, as a result of which the space within the lower shield 18 remains dry. This seal 19, 20 is, of course, also applicable to the invention according to Fig. 1.

Figs. 9 to 11 show an alternative embodiment of the trench lining, in which the shell elements comprise a number of parallel, circumferentially extending, adjoining cavities 21, through which prestressing cables 22 serving as prestressing elements are guided. These prestressing cables 22 do not only pass through the cavities 21 in the shell elements 7, but also through the cavities 23 in the head beams 12. The cavities 21 in the closing, straight upper shell elements 7' and the cavities 23 in the head beams 12 diverge at the ends facing each other, which makes it easier to guide a prestressing cable 22 through them. As the head beams 12 and the shells 8 are not in a fixed relation to each other, the cavities 23 in the head beams 12 are provided at shorter intervals than the cavities 21 in the shell elements 7, so that in each relative position still an adjoining cavity 23 can be found.

Fig. 12 shows another possible way of linking the shell elements 7 of adjacent shells 8. This consists of a screwed joint 24, which is also known from tunnel construction. The sealing of the adjacent shells is realized in this case by means of sealing elements 25 which are positioned between the adjacent shells 8 and located close to the inner and/or outer side of the shell 8. The seal is not only useful in preventing a leak of groundwater from the exterior to the interior, but also in preventing a leak from the interior to the exterior, for example in the case of calamities, such as the derailment of a train transporting chemicals.

The trench lining according to Figs. 7 to 12 can be made as follows. First of all, a shell is composed of shell elements on the pillow 17 and after all the shell elements 7 have been positioned, the entire shell 8 is pressed upwards against the head beams 12 by inflating the pillow 17. Subsequently, the prestressing cables 22 are guided through the head beams 12 and the shell elements 7 and tensioned by tensioning nuts at the ends of the prestressing cables. Then, the screwed joints 24 can be realized, after which the pressure of the pillow 17 can be lowered and the apparatus can be moved forward over the length of one shell.

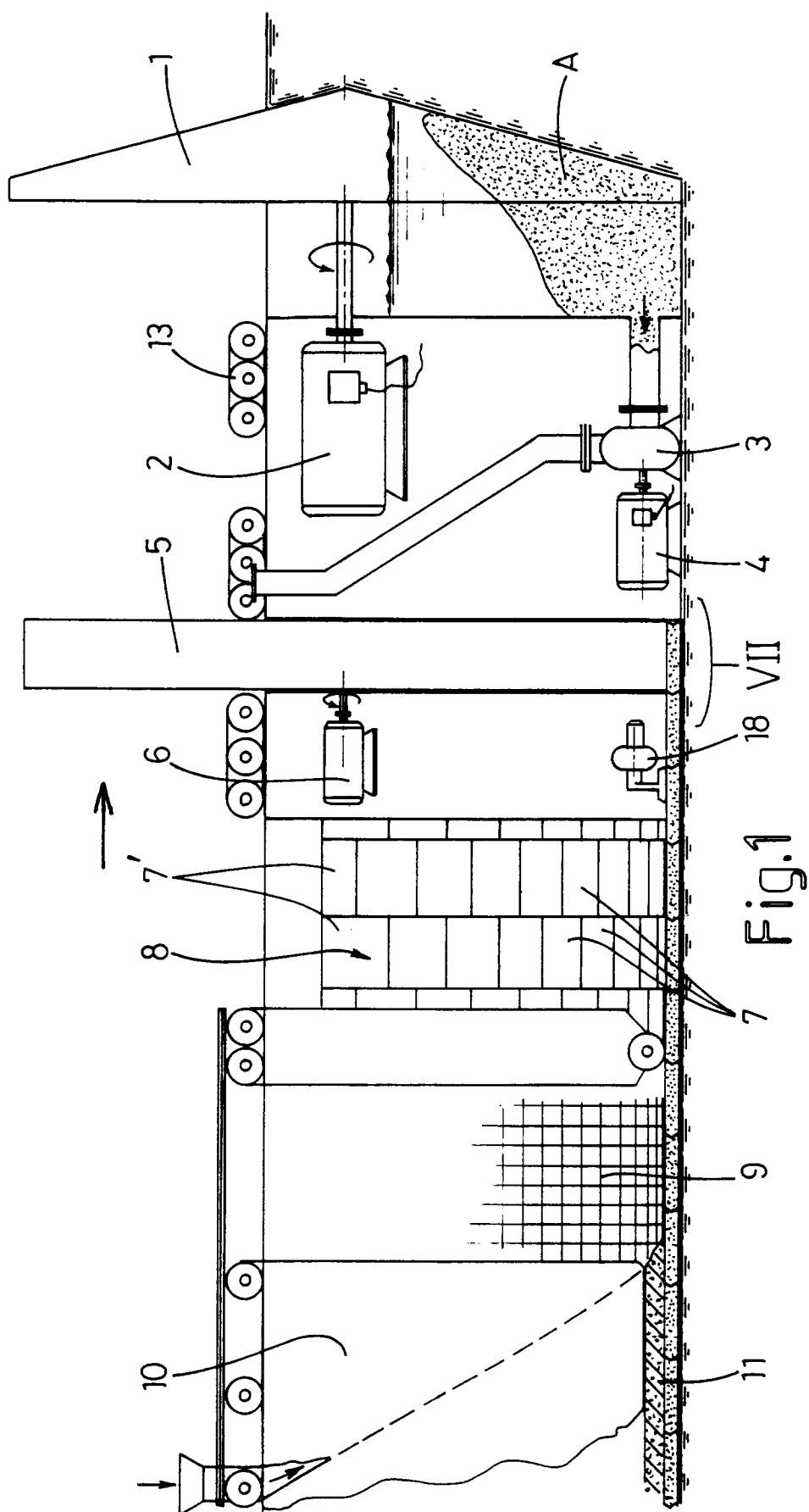
The apparatus can then be locked in the new position, for example secured by means of hydraulic clamps on the head beams 12. As a result of this, it is able to resist the hydraulic forces exerted by the semicircular water front on the shield of the apparatus. The forward movement of the apparatus can be realized by means of hydraulic cylinders which, during this forward movement, react against the shell 8 which has already been mounted.

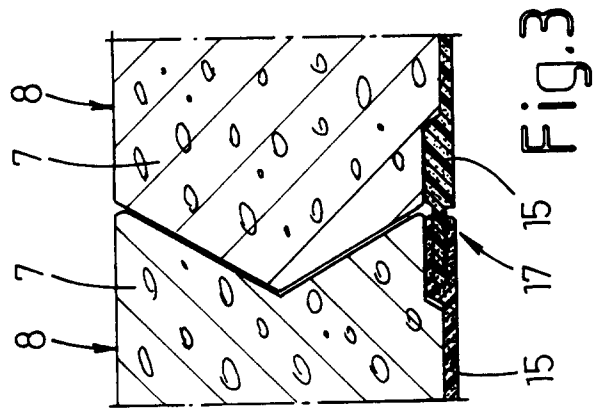
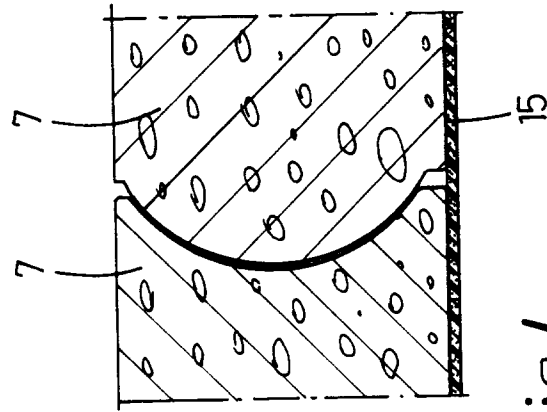
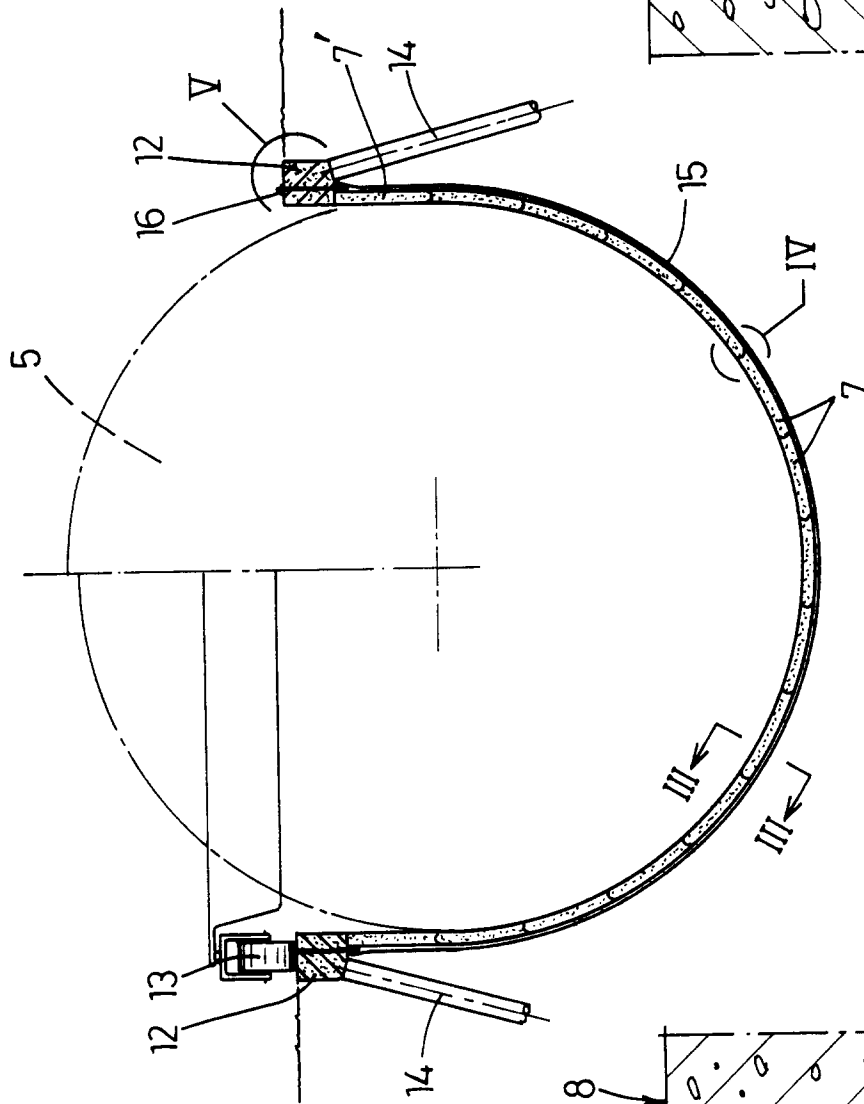
As appears from the foregoing, the invention concerns the continuous digging of a trench and the immediate, subsequent construction of a substantially semi-circular tunnel basin, both "in wet conditions" by means of a cutter-suction dredge, and "in dry conditions" by means of a digging wheel. The invention is particularly suitable for application in a slack soil with a high groundwater level, where the traditional methods with drainage by well points involve great disadvantages. This applies to many different types of soil, varying from sandy to peaty soils, but of course preferably a fairly level soil. The lined trench is not only suitable for the construction of roads, railways, tramtracks and the like, but also for the installation therein of pipes, such as sewage pipes and drinking water pipes. Other applications are conceivable as well. The nose of the apparatus is controllable to take bends, and slant shell elements can be used for providing bends in the trench lining. As a result of the semicircular shape of the trench lining, the hydrostatic pressure of the groundwater and the forces of the surrounding ground stabilize the inverse vault construction of the trench lining in the ground. Inside the trench lining composed of shell elements 7, a traditionally designed semicircular reinforced concrete basin can be cast, but it is also possible to leave the cast inner lining out, or to use only an elastomer membrane or a lining of another material.

Claims

1. Method of making a lined trench in the ground, wherein successively a trench is dug into the ground, and, immediately after that, shells are

- placed consecutively and in sealed adjoining relation in the trench, said shells being anchored by anchoring elements.
2. Method according to claim 1, wherein the shells are composed of engaging shell elements, around which or inside which a prestressing element is provided, while the shells are supported by the anchoring elements at the upper ends thereof. 5 10
 3. Method according to claim 2, wherein the shell segments are moved into the trench by a mounting wheel on which the shell elements are placed side by side, and are put in the right place by rotation of the mounting wheel. 15
 4. Method according to claim 2, wherein, inside a protecting lower shield, the shell segments are each time combined to a shell and are moved to the right level in order to be connected to a preceding shell. 20
 5. Method according to any of the claims 2 to 4, wherein the shell elements of adjacent shells have been disposed in staggered fashion in circumferential direction. 25
 6. Method according to any of the claims 2-5, wherein the shell elements are combined to a semicircular shell and wherein straight elements are placed between the semicircular shell and the anchoring elements. 30
 7. Method according to any of the preceding claims, wherein the anchoring elements are formed by girders placed on piles on both sides of the trench to be formed, which girders are positioned prior to digging the trench to guide the apparatus for implementing the method. 35 40
 8. Lining for a lined trench in the ground, which is made according to the method of any of the preceding claims, comprising adjacent, interconnected and sealed shells, and anchoring elements for anchoring the shells in the ground. 45
 9. Lining according to claim 8, wherein the shells are composed of shell elements which are interconnected by a pivoting joint, and prestressing elements which are under permanent tensile strain in circumferential direction. 50 55
 10. Lining according to claim 9, wherein the prestressing elements are fastened to the anchoring elements by tensioning means.
 11. Lining according to claim 8, 9 or 10, wherein the anchoring elements comprise girders at both sides of the trench, by which the shells are supported and which, in turn, are supported by the ends of piles functioning as anchoring elements.
 12. Lining according to any of the claims 8-11, wherein the shell elements have the shape of circle segments in order to form a semicircular shell, on which straight elements are placed which are connected to the anchoring elements.
 13. Lining according to claims 10 and 11, wherein the prestressing elements are guided through cavities extending circumferentially in the shells, as well as through cavities in the girders, said cavities of the shells and the girders diverge at the facing ends in the longitudinal direction of the trench.
 14. Apparatus for implementing the method according to any of the claims 1 to 7, comprising a leading digging machine and a trailing shell-mounting device.
 15. Apparatus according to claim 14, comprising a partly circular shield extending longitudinally and sealing the apparatus in downward direction, wherein the shield is open on the rear side and the shell-mounting device is located in the proximity of the rear side of the shield.
 16. Apparatus according to claim 15, wherein the shell-mounting device is provided with a mounting wheel onto which shell segments can be fed in order to put the shell elements in the proper places in the trench by rotation.
 17. Apparatus according to claim 15, in which the shell-mounting device comprises a mould for constructing a shell from shell elements, which mould is adjustable in height and preferably consists of a segmented inflatable pillow.





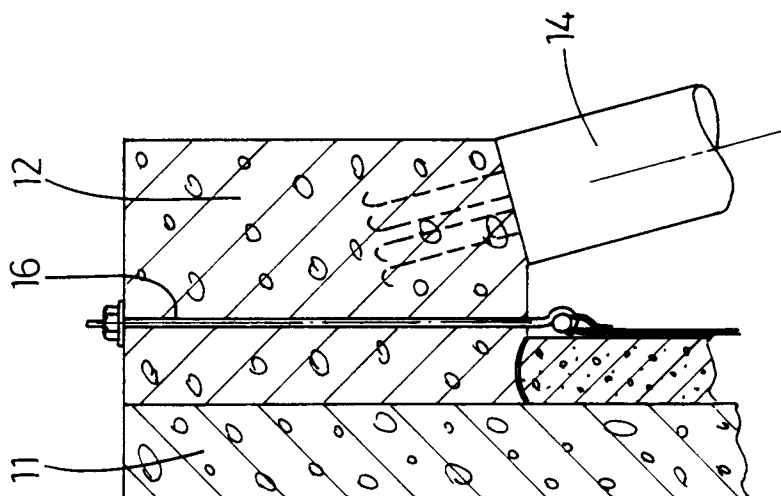


Fig. 5

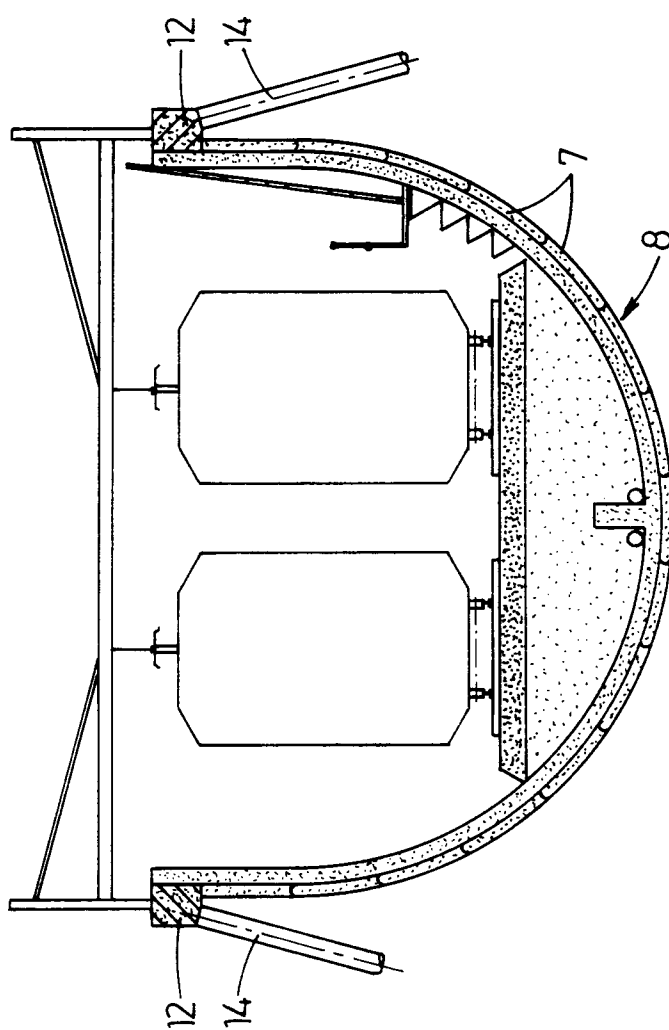
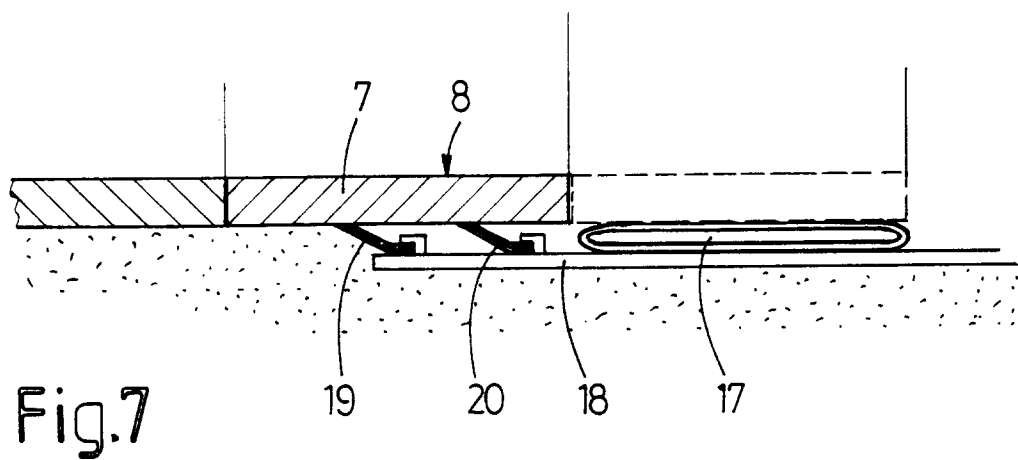
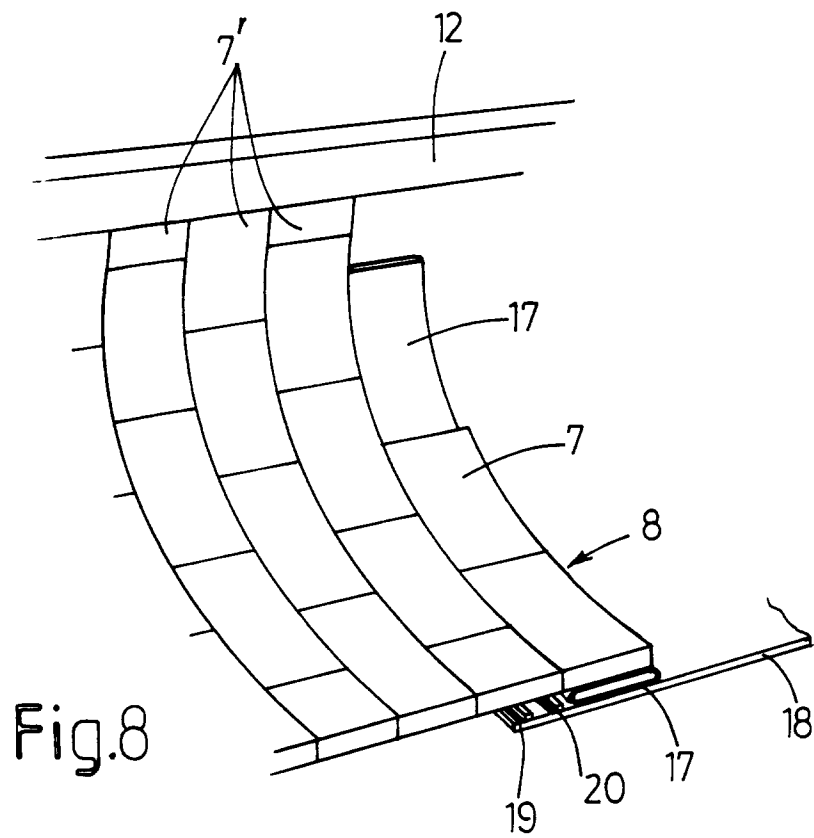
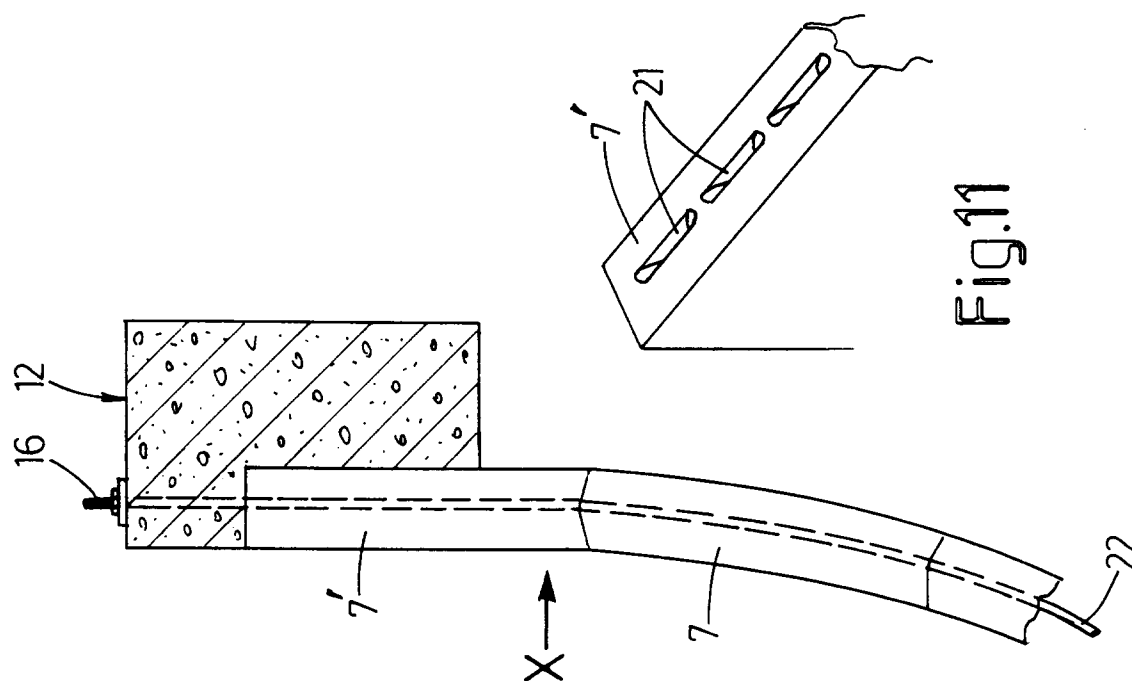
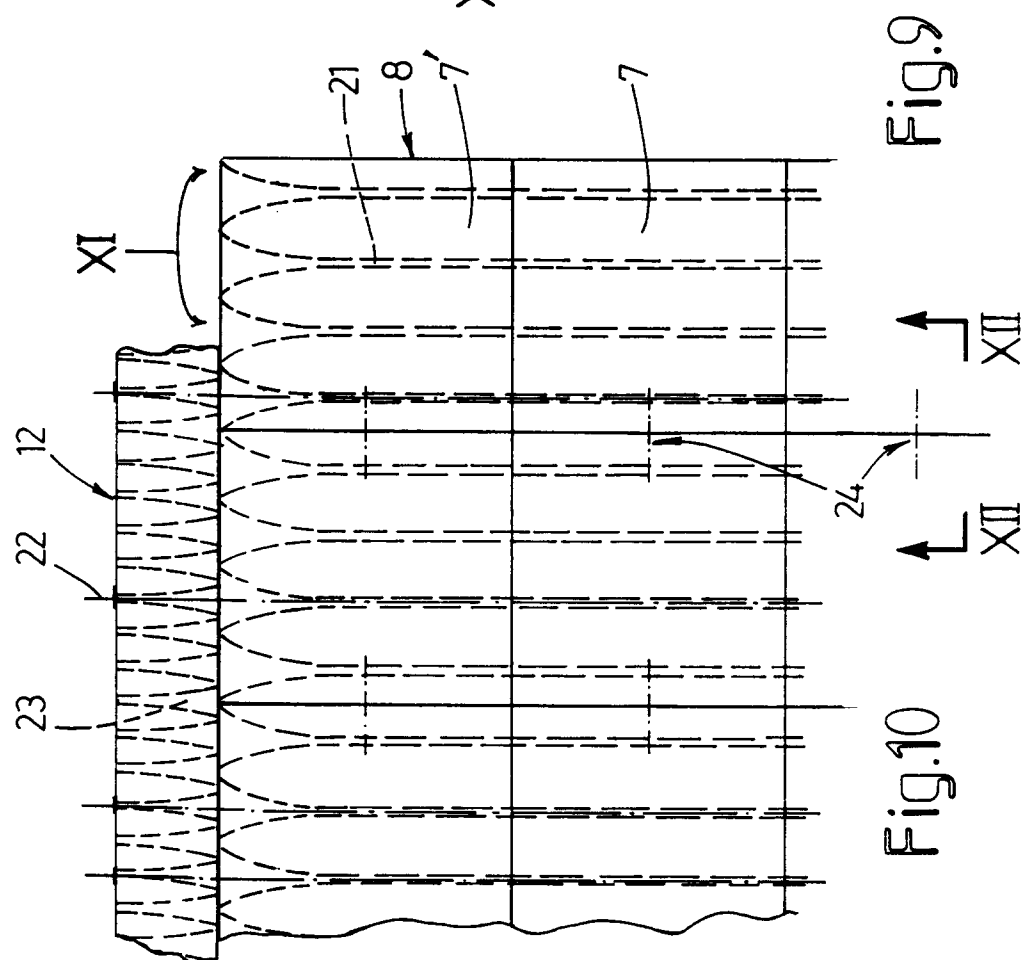


Fig. 6





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Fig. 10

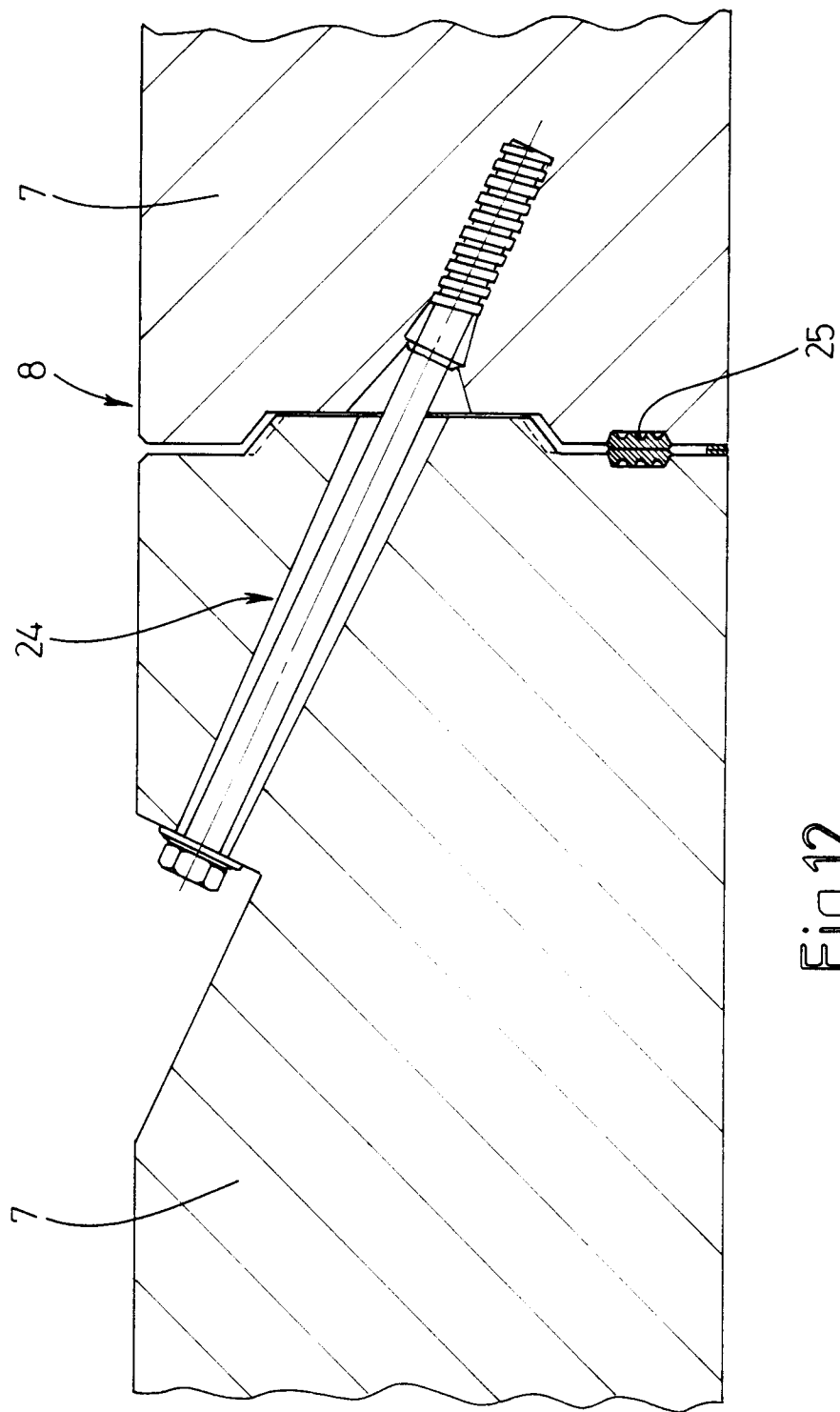


Fig.12



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 2765

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION
X	BE-A-894 870 (S.A.FRANKI N.V. ET BUREAU D'ETUDES GILBERT LESAGE S.A.)	1,14,15	E02D29/05
Y	* page 2, paragraph 3 - page 3, line 2 * * page 4, last paragraph * * page 5, paragraph 1 * * page 6, line 1 - page 8, line 1 * * figures 1-5 *	2,7	

X	GB-A-427 743 (NOFRANGO LTD.)	8,11	
Y	* page 3, line 113 - page 4, line 17 *	7,9,10, 12	
A	* figures 3,4 *	2	

Y	US-A-1 869 265 (W.LERICHE ET AL.)	2,9,10, 12	
A	* page 1, line 81 - page 2, line 21 * * figures *	13	

X	DE-A-34 46 679 (HOCHTIEF AG VORM. GEBR. HELFMANN)	14	
A	* page 9, paragraph 4 - page 10, last paragraph * * figures *	16	TECHNICAL FIELDS SEARCHED (Int.CL.6)
	---		E21D E02D E02B E02F
A	US-A-1 924 560 (W.LERICHE ET AL.) * figures *	8-13	

The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13 January 1995	Examiner Estrela y Calpe, J
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	