



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 098 065 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.05.2001 Bulletin 2001/19

(51) Int Cl.7: **E21B 7/28**, E21D 9/04,
E21D 9/02

(21) Application number: **00203798.4**

(22) Date of filing: **01.11.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**
Designated Extension States:
AL LT LV MK RO SI

(72) Inventors:
• **Ringers, Jan Antoon**
3356 LJ Papendrecht (NL)
• **Oudakker, Gerrit**
1721 DC Broek op Langedijk (NL)

(30) Priority: **02.11.1999 NL 1013459**
30.10.2000 NL 1016496

(74) Representative: **Assendelft, Jacobus H.W.**
Maartensweer 13
2265 DH Leidschendam (NL)

(71) Applicant: **VISSER & SMIT HANAB B.V.**
3350 AH Papendrecht (NL)

(54) **Method for drilling a tunnel**

(57) Method of making a tunnel tube with the aid of a tunnel drilling device, particularly for car or train traffic, with a diameter of preferably 3m to a minimum, particularly at least partly below the local ground water level

in sandy soil or another relatively easy processable underground, such as clay, peat, gravel or mixtures of these soil types, by initially making one or more at least substantially parallel guide or pilot drillings which are subsequently followed by the tunnel drilling device.

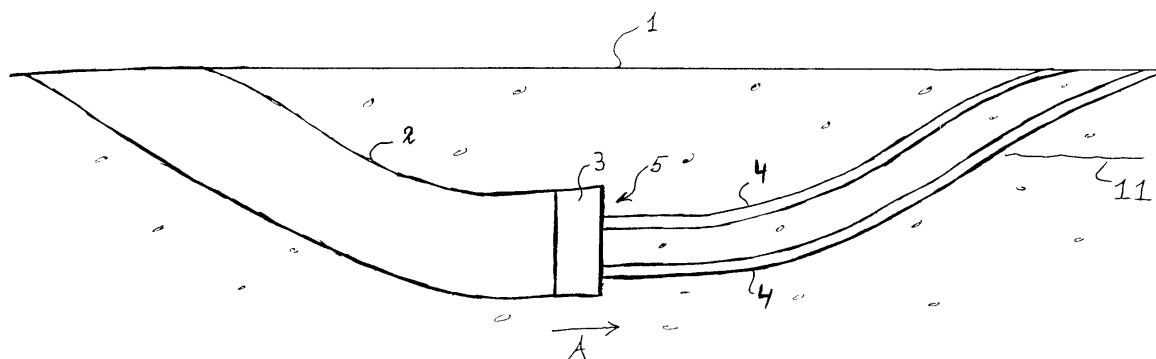


Fig. 1

EP 1 098 065 A1

Description

[0001] It is known to drill a tunnel wherein the tunnel drill device is advanced through virgin soil. This technique has several drawbacks. Supply and withdrawal of material and equipment for drilling the tunnel and installing the tunnel tube etc., such as prefabricated tunnel wall elements and drilling fluids, all takes place from one side of the tunnel drilling device. In this way the already limited space in the drilled tunnel is mainly covered by appliances, equipment and materials, and manouvring is therefor inconvenient. The limited available free space also puts limits to the dimension of the articles that are used in the tunnel, such as the prefabricated tunnel wall elements. Also the safety of the personell in the tunnel is insufficiently assured. Furthermore, this way of drilling a tunnel is relatively slow. Apart from that much effort is required to follow sufficiently accurate the desired course of the tunnel. The costs of investment in equipment are relatively high. The tunnel drilling device pushes against the tunnel wall elements to advance, such that said wall elements should be dimensioned for the forces acting during tunnel drilling.

[0002] The object of the invention is a tunnel drilling technique with which one or more of the disadvantages of the known tunnel drilling technique is eliminated.

[0003] According to the invention it is therefor suggested to initially drill one or more at least substantially parallel guide- or pilot drillings, subsequently followed by the tunnel drilling device. Particularly, effort is used such that the one or more pilot drillings come out of the soil at the side of the tunnel drilling device facing the direction of its advancement through the soil, before the tunnel drilling device starts following said pilot drillings. Particularly in this way it is made possible to supply through the pilot drillings to the tunnel drilling device material and/or equipment for drilling the tunnel.

[0004] "Tunnel drilling" here means each technique (such as also reaming) for making a hole in the underground wherein the tunnel front advances beneath the surface. The tunnel to be drilled is particularly designed for making an underground traffic tunnel, such as for car or train traffic. Therefor, its diameter measures preferably 3m as a minimum. In particular the invention is applied in sandy soil or some other relatively easily processable underground, such as clay, peat, gravel or mixtures of these soil types, wherein these undergrounds are also called "soil" or "earth". During installation and/or also thereafter, at least a length part of the tunnel installed according to the invention is at least partly, e.g. over at least 25% or at least 50% of its height, or over completely its height, beneath the local ground water level. The tunnel drilling device is preferably designed in accordance with the dimension of the tunnel tube to be installed therewith. Preferably this device has an underground rotatably fixed base frame following the advancement of the drilling front and equipped with driving means to rotatably drive one or more underground drill-

ing members which are rotatable relative to said base frame and also follow the advance,ent of the drilling front, such as drilling bits or fluid jet nozzles. Said drilling members preferably push against the rotatably fixed base frame.

[0005] The pilot drillings have a diameter substantially smaller than that of the tunnel tube, and can be made by any convenient technique, such as jet grouting or with a mechanical drilling head. The walls of the pilot drilling can be equipped with a lining such as a prefabricated tube, the front end of which is preferably moved along with the drilling front of the pilot drilling.

[0006] With the technique of tunnel drilling the tunnel wall lining is each time added at the drilling front, such the the tunnel wall lining already applied can remain in place during the complete procedure. This tunnel wall lining has at least one of the following functions: Carrying the loads from the surrounding soil; providing a neat finish of the view side of the tunnel; containing one or more provisions, such as cables to illuminate the tunnel and/or traffic control or else.

[0007] At least since the tunnel wall lining is each time added at the drilling front, this technique of underground installation of a tube differs from other techniques wherein the wall lining is each time added at the side (the back side) opposite the advancing underground front, such that the already applied wall lining moves along with the advancing front. Furthermore this technique differs from other techniques due to the underground drive system for the drilling members moving along with the drilling front. With other drilling techniques the drive system of the drilling members is located at the start of the underground tube, and a longitudinally adaptable rotating drive rod extends therefrom to the drilling members.

[0008] The invention is now further illustrated by way of some embodiments that are not intended to limit the scope of the invention.

[0009] First refering to fig. 1 and 2. Fig. 1 shows a sectional side view of a tunnel trajectory during installation, wherein the method according to the invention is applied. Fig. 2 shows the surrounding of the tunnel drilling device more in detail in sectional side view. A tunnel tube 2 is illustrated below the ground surface 1, debouching above the ground at one longitudinal end while at the opposite end (the drilling front) a tunnel drilling device 3 is present. A number of pilot drillings 4 extend from the drilling front, the longitudinal end of which opposite the drilling front also debouching outside the soil. The drilling front 5 advances in the direction of the pilot drillings (arrow A). Through one or more of the pilot drillings 4 the fluids, such as liquid and/or mortar, required for the correct action of the tunnel drilling device, are supplied to and withdrawn from the drilling front. Through one or more of the pilot drillings a pulling member 6 extends to the drilling front 5 and is connected to the tunnel drilling device 3 to apply a pulling force on the latter in the direction of the arrow A to supply at least a part of the

propulsion force required to advance the drilling front 5. Thus, the device 3 at least has to push less hard against the tunnel wall lining 7 during advancement. The device 3 each time advances stepwise and then between it and the stationary tunnel wall lining a ring gap 8 develops which subsequently is at least partly filled from the existing tunnel wall lining with supplied tunnel wall lining, whereafter the device 3 advances over one stroke again. The device 3 comprises a shell body 10 overlapping the tunnel wall lining 9 and connecting thereto in an at least substantially liquid tight manner such that no matter (such as ground water) can enter from the drilling front 5 the tunnel tube 2 extending below the ground water level 11.

[0010] The tunnel tube is preferably installed according to a hollow extending curved path relative to the earth surface, as illustrated. The tunnel tube can extend below an obstacle, such as a building, surface water body, forest, lawn, or such, such that the tunnel tube extends from the one to the opposite side of the obstacle.

[0011] The pilot drillings 4 extend with a mutual distance and are connected to the front of the device 3 with a mutual distance. The locations where the pilot drillings are connected to the device 3, and the number of pilot drillings 4 applied can be selected according to desire. While in the embodiments the tunnel tube 2 accurately follows the path of the pilot drillings along their complete length, it is also possible that the tunnel tube 2 follows said path along only a part length, to e.g. subsequently follow the path of another set of pilot drillings. The tunnel drilling device preferably surrounds at least one of the pilot drillings.

[0012] Preferably the pilot drillings are made in the one direction and the tunnel tube in the opposite direction. In case of passing an obstacle, the pilot drillings are drilled from the one side to the opposite side of the obstacle. The tunnel tube is then drilled from the opposite side to the one side of the obstacle. The advantage of this manner of working is that the auxiliary equipment used to make the pilot drillings, such as driving power and fluid sources, can be applied for the tunnel drilling device without the need to displace them.

[0013] Fig. 3 shows some profile shapes of the tunnel tube which can be made according to the present invention. Apart of that, a traditional at least substantial circular profile shape and also possibly a rectangular profile shape (fig. 4) can be made.

[0014] Fig. 5 shows schematically a front view of the device 3, wherein the working areas 12 of the drilling members are shown. By application of a plurality of relatively small drilling members each having a circular working area 12, a tunnel tube differing from the circular shape can be made. Each drilling member can be a drilling head with bits known as such, spinning around a central spinning axis extending under right angles to the drawing surface of fig. 5. In stead of bits, the drilling head can have e.g. fluid jet nozzles ejecting a fluid jet eroding the surrounding soil material. Preferably, adjacent drill-

ing members spin oppositely.

[0015] Fig. 6 shows a sectional side view and fig. 4 shows the corresponding view of fig. 6 in the direction of the arrow VII of an alternative embodiment of the tunnel drilling device 3 for making a tunnel tube with rectangular profile. The drilling members, the working areas 12 of which are shown, can now spin around an axis 13 extending making an angle with the longitudinal direction of the tunnel tube. As with fig. 5, the working areas 12 are within a soil knife 14 having a slanted cutting edge extending downwardly to the back as view from aside. This soil knife can be eliminated. It is also feasible, to use the soil knife without additional drilling members or with different drilling members.

[0016] Fig. 8 and 7 show the profile of the tunnel tube 2. In fig. 8 a wheeled carriage 15 is located in the tunnel tube 2. A prefabricated tunnel wall lining segment 16 of steel sheet is supported by the carriage. The segment 16 preferably makes a closed section. It is supplied to the tunnel tube 2 in collapsed mode, preferably by pivots along one or more pivoting lines. The segment 16 can advance through the tunnel tube from its begin and towards the drilling front to extend the tunnel tube wall lining over a distance that at least substantially equals the distance over which the device 3 is advanced since the last time the tunnel tube wall lining is extended. At the location of destination the segment can be unfolded into its final shape, corresponding to the tunnel tube profile (fig. 7). By lining the tunnel wall with metal, preferably sheet type, an air tight, fire proof tunnel tube of relatively low weight is provided.

Claims

1. Method of making a tunnel tube with the aid of a tunnel drilling device, particularly for car or train traffic, with a diameter of preferably 3m to a minimum, particularly at least partly below the local ground water level in sandy soil or another relatively easy processable underground, such as clay, peat, gravel or mixtures of these soil types, by initially making one or more at least substantially parallel guide or pilot drillings which are subsequently followed by the tunnel drilling device.
2. Method according to claim 1, wherein through said pilot drillings material and/or equipment for drilling the tunnel, such as liquid or mortar, are supplied to and/or withdrawn from the tunnel drilling device.
3. Method according to claim 1 or 2, wherein the pilot drillings are carried out in the one direction and the tunnel tube is made in the opposite direction and preferably provision is made that the one or more pilot drillings arrive above the ground at the side of the tunnel drilling device facing the direction of its advancement through the ground, before the tunnel

drilling device starts to follow said pilot drillings.

4. Method according to any of claims 1-3, wherein the walls of a pilot drilling are provided with a lining such as a prefabricated tube, the front end of which is preferably moved with the drilling front of the pilot drilling. 5
5. Method according to any of claims 1-4, wherein the tunnel drilling device has an underground rotatably fixed base frame following the advancement of the drilling front and having driving means for rotatably driving one or more underground drilling members which are rotatable relative to said base frame and also follow the advancement of the drilling front, such as drilling bits or fluid jet nozzles, preferably pushing against the rotatably fixed base frame. 10 15
6. Method according to any of claims 1-5, wherein a pulling member (6) extends through at least one of the pilot drillings and is connected to the tunnel drilling device (3) to exert a pulling force on it. 20
7. Method according to any of claims 1-6, wherein a shell body (10) is overlapping the tunnel wall lining (9) connecting at least substantially fluid tight thereto such that no matter can penetrate the tunnel tube (2). 25
8. Method according to any of claims 1-7, wherein the tunnel tube is installed according to a hollow extending curved path relative to the earth surface and preferably extends below an obstacle, such as a building, surface water body, forest, lawn, or such. 30 35
9. Method according to any of claims 1-8, wherein a prefabricated tunnel wall lining segment (16) of preferably steel sheet and preferably providing a closed section is supplied to the drilling front in collapsed mode, preferably by pivoting along one or more pivoting lines, and is subsequently unfolded into its final shape, adapted to the tunnel tube profile. 40
10. Method according to any of claims 1-9, wherein the tunnel drilling device (3) has a plurality of relatively small drilling members, each covering a working area (12) around an own axis. 45

50

55

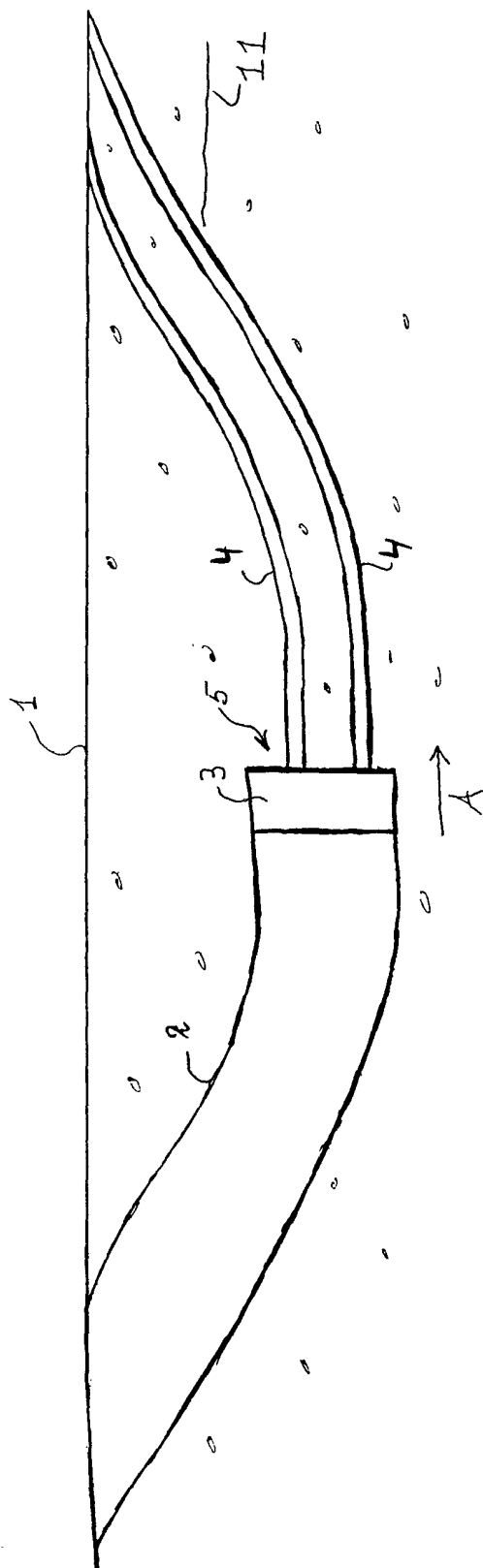


Fig. 1

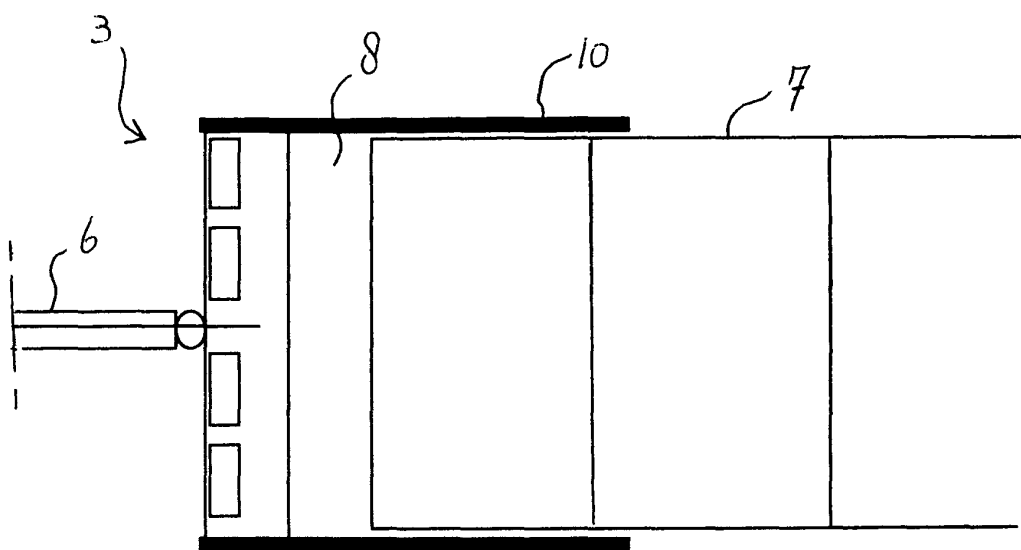


Fig. 2

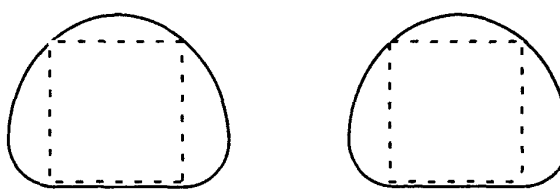


Fig. 3

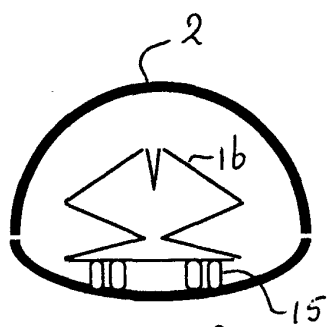
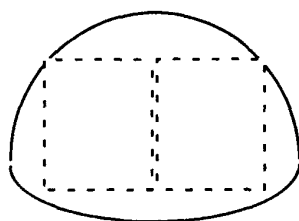


Fig. 8

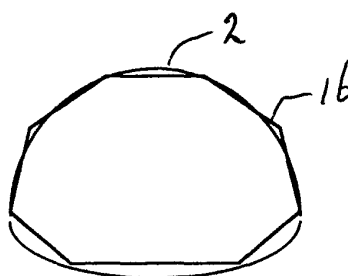
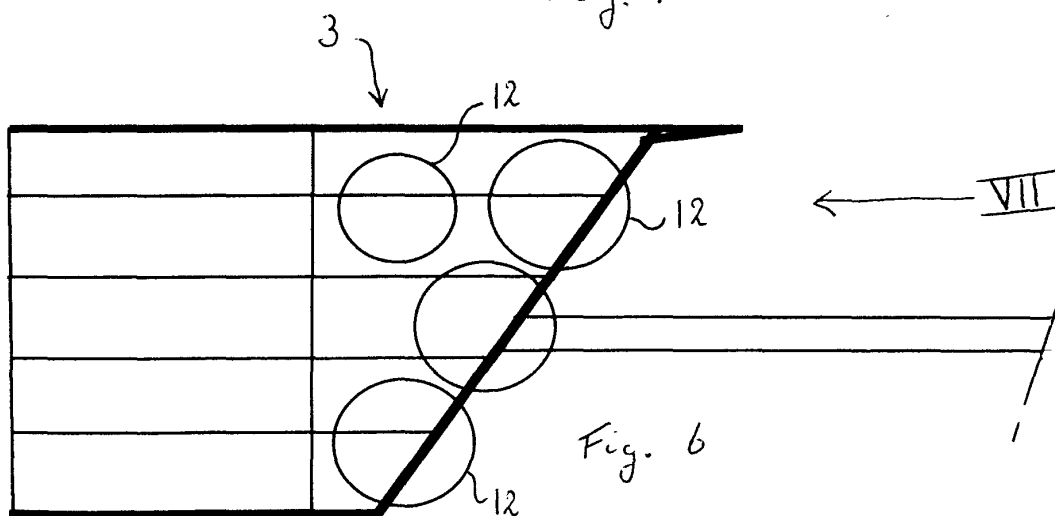
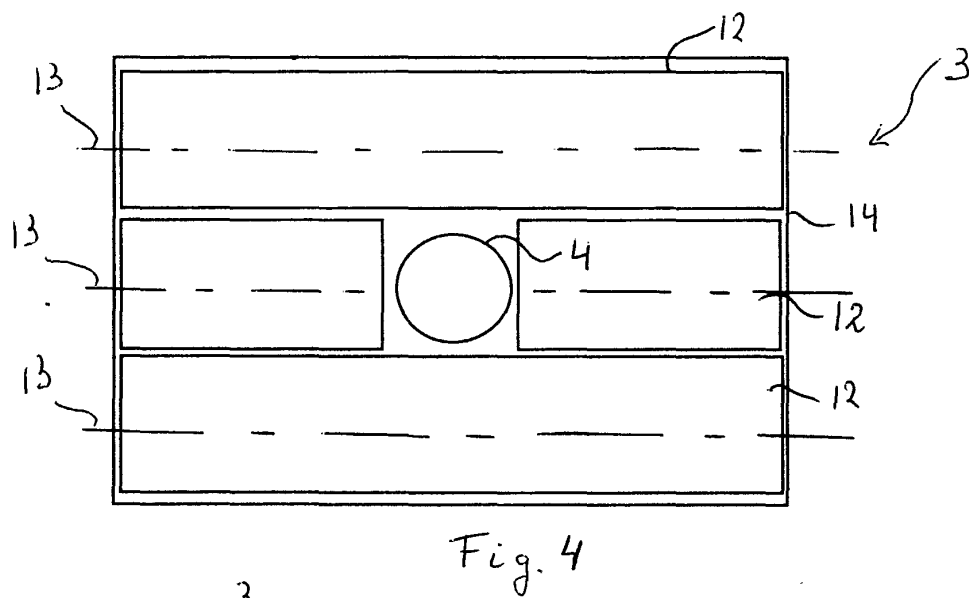
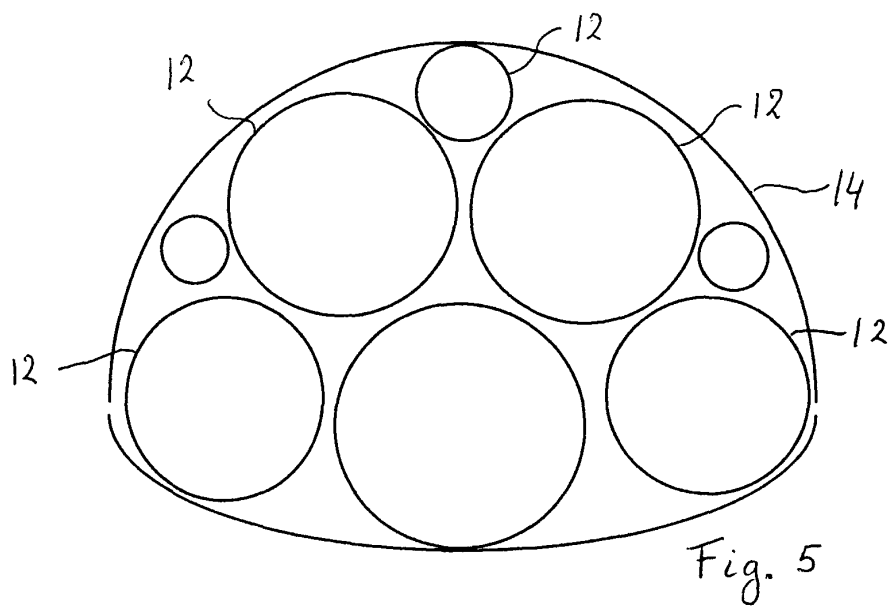


Fig. 7





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 3798

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.7)
X	EP 0 890 708 A (HEEREMA ONDERGRONDSE INFRASTRU) 13 January 1999 (1999-01-13)	1-4,6	E21B7/28
Y	* the whole document *	5,7-10	E21D9/04
Y	US 4 102 413 A (JOHNSTON FREDERICK ERIC) 25 July 1978 (1978-07-25) * abstract; figure 2 *	7	E21D9/02
Y	US 3 894 402 A (CHERRINGTON MARTIN D) 15 July 1975 (1975-07-15) * figures 1,2 *	8	
Y	US 4 124 985 A (MAIMETS LEMBIT) 14 November 1978 (1978-11-14) * abstract; figures *	9	
Y	US 5 628 585 A (PARISH II ROBERT O ET AL) 13 May 1997 (1997-05-13) * column 3, line 50 - line 58; figure 1 *	5,10	
A	EP 0 763 648 A (RD TRENCHLESS LTD OY) 19 March 1997 (1997-03-19) * figures *	1,5,7	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	US 5 314 267 A (OSADCHUK MARK) 24 May 1994 (1994-05-24) * the whole document *	1	E21B
A	EP 0 741 227 A (HITACHI CONSTRUCTION MACHINERY) 6 November 1996 (1996-11-06) * column 15, line 34 - line 38; figure 24 *	1	E21D
A	US 4 456 078 A (ADAM ARTHUR J L) 26 June 1984 (1984-06-26)		
A	US 5 366 029 A (BECK III AUGUST H) 22 November 1994 (1994-11-22)		
		-/--	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 March 2001	Examiner Fonseca Fernandez, H
<p>CATEGORY OF CITED DOCUMENTS</p> <p>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</p> <p>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</p>			

EPO FORM 1503 03.02 (F04C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 3798

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.7)
A	US 4 142 598 A (MAXSTED MALCOLM D) 6 March 1979 (1979-03-06) -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 March 2001	Examiner Fonseca Fernandez, H
<p>CATEGORY OF CITED DOCUMENTS</p> <p>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</p> <p>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</p>			

EPO FORM 1503 03/82 (Pd4001)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 20 3798

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-03-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0890708 A	13-01-1999	EP 0890707 A	13-01-1999
		EP 1072754 A	31-01-2001
		JP 11081869 A	26-03-1999
US 4102413 A	25-07-1978	CA 1056366 A	12-06-1979
US 3894402 A	15-07-1975	AU 8282875 A	13-01-1977
		BE 831519 A	17-11-1975
		BR 7504618 A	06-07-1976
		CA 1047481 A	30-01-1979
		CH 604060 A	31-08-1978
		DE 2531582 A	29-01-1976
		EG 11759 A	31-12-1977
		ES 439516 A	01-06-1977
		FR 2279009 A	13-02-1976
		GB 1501919 A	22-02-1978
		JP 1336349 C	11-09-1986
		JP 51036711 A	27-03-1976
		JP 60059398 B	25-12-1985
		NL 7508627 A,C	21-01-1976
		YU 183175 A	28-02-1982
US 4124985 A	14-11-1978	US RE30929 E	11-05-1982
US 5628585 A	13-05-1997	AU 712736 B	11-11-1999
		AU 5578696 A	18-11-1996
		CA 2219642 A	31-10-1996
		CN 1269003 A	04-10-2000
		EP 0870151 A	14-10-1998
		WO 9634225 A	31-10-1996
EP 0763648 A	19-03-1997	FI 954309 A	15-03-1997
		US 5791419 A	11-08-1998
US 5314267 A	24-05-1994	NONE	
EP 0741227 A	06-11-1996	JP 8303169 A	19-11-1996
		CN 1136126 A	20-11-1996
US 4456078 A	26-06-1984	NONE	
US 5366029 A	22-11-1994	NONE	
US 4142598 A	06-03-1979	AU 514796 B	26-02-1981
		AU 3620478 A	22-11-1979
		CA 1083135 A	05-08-1980

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 20 3798

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-03-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4142598 A		IT 1094785 B ZA 7802787 A	02-08-1985 30-05-1979

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82