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Applicant: Finic B.V.  
Weena 723 Postbus 29123  
NL-3001 GD Rotterdam(NL)

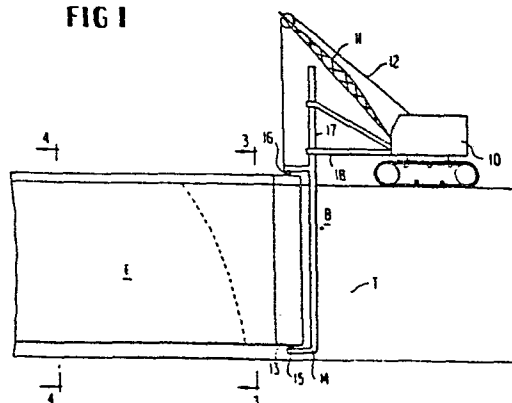
Inventor: Ressi di Cervia, Arturo  
450 West End Avenue  
New York, NY. 10024(US)

Representative: Blum, Rudolf Emil Ernst et al,  
c/o E. BLUM & CO. Vorderberg 11  
CH-8044 Zürich(CH)

Method and apparatus of constructing a novel underground impervious barrier.

A trench or slot is excavated along the desired line of the impervious barrier in the presence of a bentonite slurry. A double layered plastic film or sheet joined or folded at the bottom of the trench (T) to form a sheath or envelope (F) and open at the top and of sufficient vertical extent to extend above the ground and drape on both sides of the trench (T) is installed in the trench and as the plastic sheath or envelope (F) is installed in the trench (T) it is hydraulically backfilled between the two facing surfaces thereof with a backfilling material (30) having a greater density than the density of the bentonite slurry (B) to sink the double layer plastic film or sheet (F) to the bottom of the trench (T) and displace the bentonite slurry (B) forward in the trench (T) toward the end being excavated.

FIG 1



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Method and apparatus of constructing a novel underground  
impervious barrier

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This invention is directed to a method and apparatus for constructing a novel underground impervious fluid barrier which is useful for pollution control, impounding water, oil and other flowable material, especially in  
5 populated areas, where government and industries are faced with the problem of arresting underground seepages and situations where there is little or no gradient between the outside water table and the polluted area inside.

10 Lining underground slurry trenches with impervious films such as rubber liners, plastic sheets, foils and the like has been attempted prior to this invention but they have not been particularly successful. (See page 130 of R.G.H. Boyers' text entitled "Structural and Cut-  
15 Off Diaphragm Walls" John Waley & Sons). In Ranney Patent 2,048,710, an apparatus is disclosed for constructing an underground wall in which two rolls of lining material are carried inside wings of an excavating shield for unrolling the lining material to line the walls of the  
20 trench preparatory to filling of the trench with the desired wall material. There is no teaching in Ranney

of utilizing a lining material which is folded (or otherwise joined) at the bottom and of sufficient height to comfortably drape over the sides of the trench. A feature of the process of the present invention is the use of  
5 the fill material to weight the lining material and displace the bentonite (using the lining material to transmit the displacing force to the bentonite). In Zaklewicz Patent 3,603,099 and Caron et al Patent 3,759,044, a plastic sheet is immersed in a bentonic mud filled trench.  
10 In the Zaklewicz patent the filling material is added to each side of the plastic membrane to displace the excavating slurry and in the Caron et al patent, the plastic

sheeting is immersed in a cementitious bentonite filled trench and remains there until the wall material has set. Neither of these prior art references disclose the concept of applicant's double or folded plastic membrane nor is there disclosed a membrane of sufficient vertical height to drape over the sides of the trench. In the present invention, the double layer end fold results in a basic wall structure not disclosed in these prior art references.

10       The use of the lining for protecting underground pipes and conduits has been known in the art as is disclosed in Grodsky Patent 2,007,969 and in Keene Patent 3,675,432. However, these are non-analogous to the present invention and neither of these is disclosed in  
15 the context of a slurry trench excavating process and obviously, do not in any sense teach the depth of the wall and process as disclosed herein and do not teach or suggest a membrane of 30 to 40 feet in depth containing industrial pollutants or impounding water or  
20 other flowable materials. In Grether et al Patents 3,298,183 3,218,810 and 3,182,459, a fluid barrier is disclosed for water impoundment and/or channelization but there is no underground structure contemplated, and the double folded material is simply folded at the top above the ground and  
25 buried to anchor same against the force of the upstream water.

      The basic object of the present invention is to provide an improved impervious underground wall structure and an improved method and apparatus for constructing  
30 same, particularly for pollution control.

      A basic feature of the invention is that the liner is a folded plastic liner (forming a sheath or envelope for the backfill material) of sufficient height so that both sides thereof can extend and drape over the sides of the slurry filled trench so that the backfill material,

which, preferably, is hydraulically placed and of greater density than the slurry in the trench, carries the fold line to the bottom of the trench and displaces the bentonite slurry towards the end of the excavation where the excavation is taking place thereby reducing the amount of slurry needed. The double layer plastic is unrolled along the trench, until extending up above the surface is opened up and the backfill material is hydraulically placed between the sheets. Typically the backfill material may be a mixture of sand and water which will have two effects. It will sink the plastic to the very bottom of the trench and make it adhere to the sides of the trench and will displace forward the bentonite, reducing the need for a lot of bentonite for excavation. The wall structure resulting from this technique is novel in that the impervious barrier that is constructed in the earth will consist of an area of soil adjacent the excavation which has been permeated by bentonite (e.g. the side walls of the trench), a bentonite cake, the plastic membrane, the backfill material inside the plastic membrane (typically sand or coarse granular material) and the same system repeated again on the opposite trench wall side.

The advantages of the system are that it assures an absolute water tightness by two identical pollutant barrier systems in series, - the soil permeated bentonite the bentonite cake and the plastic membrane. Moreover, the backfill material is used to sink the plastic sheath or envelope to the bottom of the trench, hence, once the initial insertion in the trench of the roll and a preliminary backfilling is accomplished, the plastic material is unrolled or unfolded from an accordion fold and floats in the trench or slot until it is opened up at the top and the backfill material is inserted and the

bentonite slurry is displaced to the opposite end of the trench or slot.

The above and other objects, advantages and features of the invention will become more apparent from the following specification taken in conjunction with the accompanying drawings wherein:

Figure 1 is a sectional elevational view of an excavation illustrating one embodiment of the invention,

Figure 2 is a top plan view of the trench illustrated in Figure 1,

Figure 3 is a sectional view taken on the lines 3-3 of Figure 1 illustrating the folded plastic sheet, sheath or envelope liner prior to being filled with a backfill material,

Figure 4 is a sectional view taken on lines 4-4 of Figure 1 illustrating the plastic sheet, sheath or envelope liner after it has been filled with backfill material,

Figure 5 is a sectional elevational view of a further embodiment of the invention illustrating the plastic liner being fed into the trench from a rack with an accordion folded liner, and

Figure 6 is a sectional view taken on lines 6-6 of Figure 5.

The basic method of this invention for constructing an underground pollution control barrier comprises excavating a narrow trench or slot along the desired line of the pollution control barrier in the presence of a bentonite slurry. It will be appreciated that while bentonite is the preferred slurry, other materials which perform the same function as the bentonite slurry may be used but bentonite slurry is preferred since it can be closely tailored to have the property of permeating the soil adjacent and contiguous to the excavation to form a first barrier to the polluting substance. In addition, a bentonite cake forms on the wall during the excavating

process to serve as a second barrier to the flow of any polluting substances. After forming the initial trench excavation or slot and while the trench is full of the slurry maintaining it open in the way disclosed in Veder  
5 Patent 3,310,952, a sheath or envelope constituted by a double layered plastic membrane which is folded at the bottom of the trench and open at the top and of sufficient vertical extent to extend above the ground surface on both sides of the trench, is inserted into the trench  
10 or slot. The trench or slot T in Figure 1 has been excavated by clam shell, backhoe, trenching apparatus and the like, to the desired depth of the barrier. Typically, this invention will apply to depths of 30 to 40 feet and, in the usual case about 20 feet or down to the water  
15 table level. In the illustrated embodiment, the trench T is filled with a bentonite slurry B to the top of the trench slot all in accordance with the teachings of Veder Patent 3,310,952, incorporated herein by reference. A portion of the loading by the lifting and placing devices  
20 10 may be transferred to the slurry by the use of the slurry float technique as disclosed in my application Serial No. 173,538. Lifting and placing device 10 has a boom 11 carrying control cables 12 to a plastic film pay  
out roll 13. A frame 14 having bearings 15 and 16 for  
25 roll 13 is maintained in vertical relation by stabilizing members 17 and 18 extending from lifting and placing device 10. The plastic film F (forming the backfill sheath or envelope) which, under certain circumstances can be reinforced or complemented by a woven fabric WF  
30 to give it additional strength, is capable of withstanding the stress and avoidance of possible tears.

After the formation of the initial trench portion, the end of the sheath or envelope constituted by the plastic film F is opened up and each of the ends is draped over the sides of the trench so that the fold

line lies in approximately the center of the trench.  
In this sense, the end then will be floating on the  
bentonite layer and at this time, the backfill material  
has begun to be hydraulically placed between the sheets  
5 of plastic. Typically, a mixture of sand and water can  
be used which will have two effects. It will sink the  
plastic to the bottom of the trench or slot and make it  
adhere to the sides of the trench and will also displace  
the bentonite slurry forward in the trench by the force  
10 exited through the plastic layers thereby reducing the  
need for a lot of bentonite for the excavation. On the  
other hand, the end of the trench can be sealed and with  
a rigid bar member forcing the end of the envelope down  
to the bottom of the trench and then the envelope or  
15 sheath is filled with the backfill material as described.  
Of course, the end of the sheath can be heat sealed along  
a vertical line joining the two sides, if desired.

By using a coarse granular material as a fill within  
the plastic, a very pervious layer enclosed in plastic  
20 can act as a filter. Draining the filter material is an  
excellent method of maintaining the effectiveness of the  
barrier and, with a minimum amount of pumping at long  
intervals, guaranteeing that any pollutant which crosses  
the initial barrier is collected and eliminated.

25 In Figure 3, the plastic film is shown as it is  
being unrolled from roll 13. As shown in the top plan  
view of Figure 2, the ends 20, 21 of the plastic film  
are draped over the surface above the side walls of the  
trench. The bentonite slurry B in trench T exerts a  
30 hydraulic head on the sides of the plastic film which is  
immersed thereby forcing any air out of the construction.  
Thus, the hydraulic placement of the backfill material  
applies a pressure against the inside surfaces of the  
plastic film thereby forcing and displacing the bentonite  
slurry towards the excavating end of the trench thereby



reducing the amount of bentonite required to perform the excavation.

It will be appreciated that the excavating slurry can in fact be a cementitious bentonite mixture and the backfill material 30 can itself be a self-hardening substance such as a cement-bentonite mixture.

When the end of the roll 13 is approached, the backfilling is withheld for a distance of approximately 50 feet. The roll 13 is then lifted out of the excavation and the remaining portions completely unrolled and washed of bentonite material and laid flat. A second roll is then placed on the carrier and its end unrolled and two ends are then welded together using conventional plastic sheet welding. For example, R.F. Welding or other heat seam welding can be utilized to join the end of the new roll to the end of the old roll. The new roll is then lowered back into the trench or slot T and the backfilling operation resumes along with the excavating of the forward end of the trench.

20 In this regard, instead of the roll being vertical and instead of a fold at the bottom of the trench, the roll is not folded but is simply rolled along the top of the trench so that it floats on the bentonite slurry. The ends of the roll extend quite some distance beyond the edges of the excavation and the end of the roll is then pushed to the bottom of the trench either by the backfill material or by a rigid rod and the backfilling operation commenced. In this case, the roll per se never goes below the surface but the ends thereof is open and clear for performing the welding operation to add the next roll on.

Larger rolls can be accommodated by varying the thickness of the trench along the line of the barrier. Thus, as the roll is payed out, the trench can be made narrower, this approach having the advantage of permitting longer rolls and minimizing the number of joints.

Referring now to Figure 5, a backhoe excavator 40 is shown excavating the trench or slot T' which is maintained full of bentonite slurry B. A rack 41 with a accordion folded liner F' is coupled by pulling 5 cables or a draw bar to backhoe 40. In this method, the laying of the plastic comprises in folding it up accordion style in a large roll above ground with the backfill material opening up the folds and pushing the plastic down into the trench as illustrated in Figure 5. The 10 joining of the ends of the film F' of a new roll to the old roll does not thereby require the removing of the expended roll as in the embodiment of Figure 1. As shown in Figure 6, there is as in the case of Figure 4, a bentonite jell of a zone of bentonite intrusion 5, a 15 bentonite cake 6 and plastic layer or sheet 7 on each side of the trench and the backfill material of sand, gravel etc. It will be appreciated that the plastic film can be payed out from a pair of parallel rolls and prior to entry to the trench heat sealed or otherwise 20 wise bonded at the lower edges of the two rolls to form the joint that will eventually be at the bottom of the trench.

Thus, there has been disclosed an improved process and apparatus for constructing a novel impermeable membrane of 30 to 40 feet in depth which is particularly 25 useful for containing areas of industrial pollutants and arresting underground seepage where there is little or no gradient between the outside water table and the polluted area inside. Moreover, the invention has 30 applicability to forming water and petroleum impoundments, cut-off walls and water channelization at relatively high rate of installation and at relatively low cost.

While I have disclosed several embodiments of the invention and suggested other modifications, it will be apparent that many modifications which will be obvious

to those skilled in the art and it is intended that such modifications be encompassed within the spirit and scope of the claims appended hereto.

CLAIMS

1. An underground fluid material flow control barrier: comprising
  - 1) a narrow slot in the earth having a length extending across the expected pollution path and a depth  
5 extending at least to the water table,
  - 2) bentonite impregnating the earth walls of said slot and forming a bentonite cake on the inner surfaces thereof,
  - 3) a plastic sheath in said narrow slot and in  
10 contiguous relation to all surfaces in said slot and,
  - 4) a material filling said sheath having a density greater than bentonite slurry used in forming said narrow slot.
2. The underground fluid material flow control  
15 barrier defined in Claim 1 including means in said sheath for draining the backfill material.
3. The underground fluid material flow control barrier defined in Claim 1 wherein said material filling said sheath is sand.
- 20 4. The underground fluid material flow control barrier defined in Claim 1 wherein said material filling said sheath is a self-hardenable wall forming material.
5. The underground fluid material flow control barrier defined in Claim 1 wherein said material filling  
25 said sheath is a mixture of cement and bentonite.
6. The underground fluid material flow control barrier defined in Claim 1 wherein said plastic sheath includes a strengthening material.

7. The underground fluid material flow control barrier defined in Claim 6 wherein said strengthening material is a woven fabric.

8. The underground fluid control barrier defined in Claim 1 wherein soil material filling said sheath is a coarse granular material, and means for draining said coarse granular material.

9. A pollution control barrier comprising  
a narrow slot in the earth, said slot extending  
10 downwardly in the earth at least to the water table,  
a plastic sheath contacting at least the sides  
and bottom of said slot, and  
a backfill material contained within said plastic sheath.

15 10. A method of constructing an underground fluid barrier comprising:  
excavating a trench along the desired line of  
said barrier in the presence of a bentonite slurry, said  
trench having a pair of facing side walls,  
20 and simultaneously installing a flexible impervious lining material adjacent each of said facing walls  
and along the bottom of said trench and backfilling the  
space between said lining material and displacing said  
bentonite slurry in a selected direction by said lining  
25 material.

11. The method defined in Claim 10 wherein said lining material is plastic.

12. The method defined in Claim 10 wherein said backfilling material is a coarse granular material which in bulk, is surrounded on at least the bottom and sides

thereof by said lining material and as installed displaces said bentonite slurry in said direction.

13. The method defined in Claim 10 wherein said flexible impervious lining material is constituted by  
5 a pair of plastic sheets which have been hermetically joined at their contiguous lower edges to form an impervious envelope in said trench.

14. A method of constructing an underground pollution control barrier comprising:

10 excavating a trench along the desired line of said pollution control barrier in the presence of a excavation slurry,

installing a double layered plastic membrane which is joined at the bottom of the trench and opened  
15 at the top and of sufficient vertical extent to extend above the ground surface on both sides of said trench,

as said double layer plastic membrane is installed in the trench, hydraulically backfilling between the two facing surfaces of said double layered plastic  
20 membrane with a backfilling material, said backfilling material having a density greater than the density of the bentonite slurry to sink the membrane to the bottom of said trench and displace the bentonite slurry forward in the trench toward the end being excavated and reduce  
25 the amount of bentonite needed for the excavation,

whereby said pollution control barrier is constituted by the areas of the two earth side walls of the trench each side wall being permeated by bentonite and having bentonite cake contiguous thereto, a plastic membrane and the backfill material between the facing surfaces of said plastic membrane.

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FIG. 1

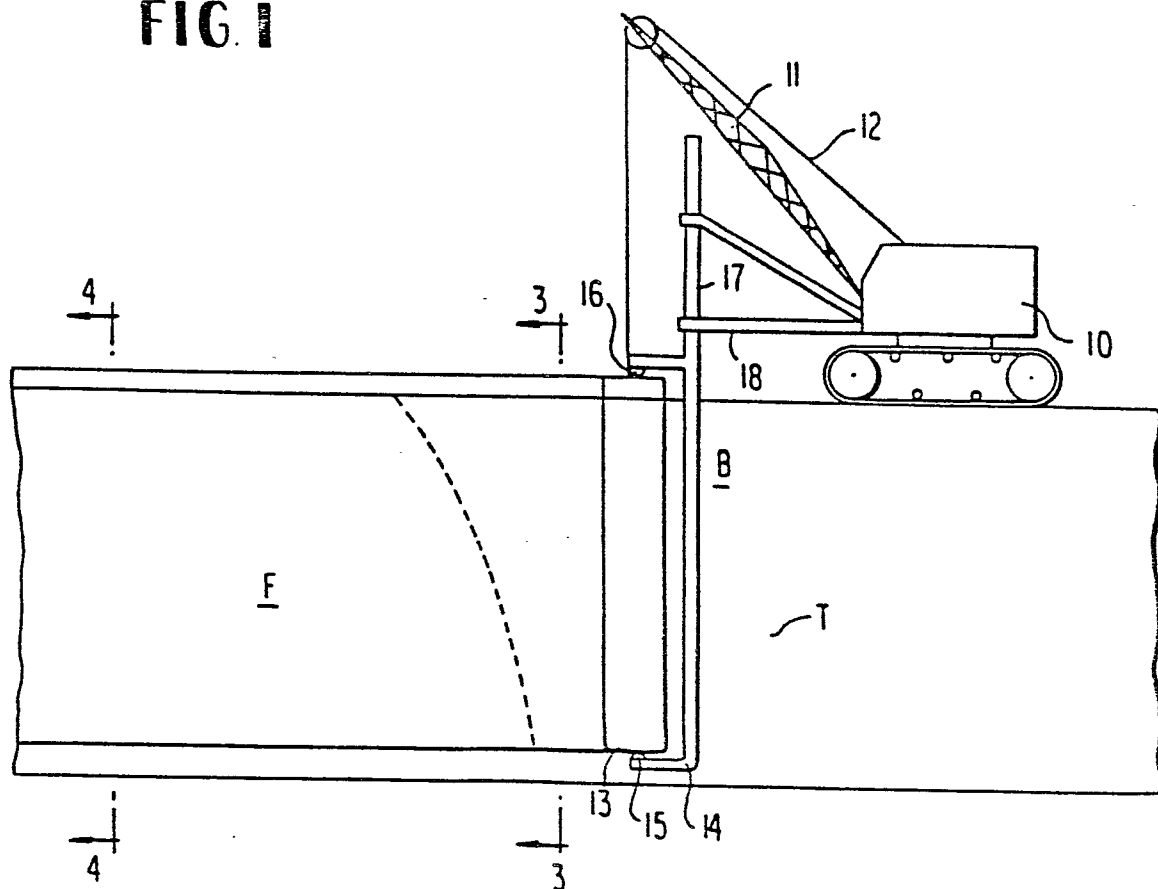


FIG. 2

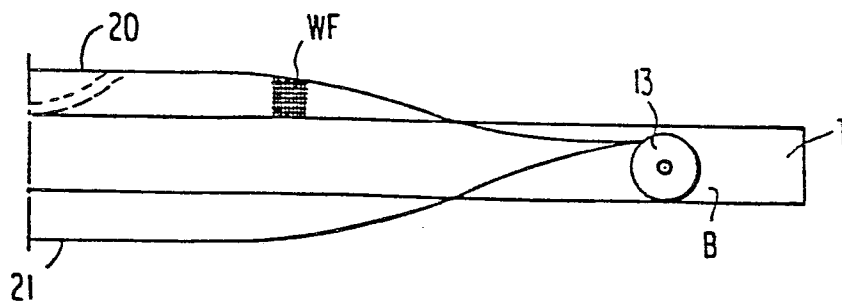


FIG. 3

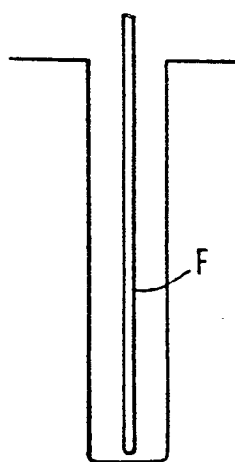
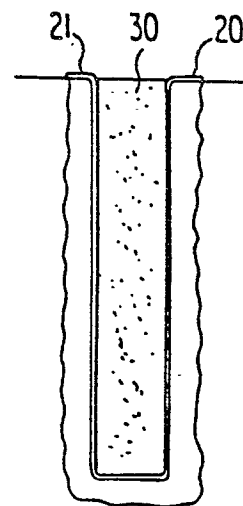


FIG. 4



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FIG. 5

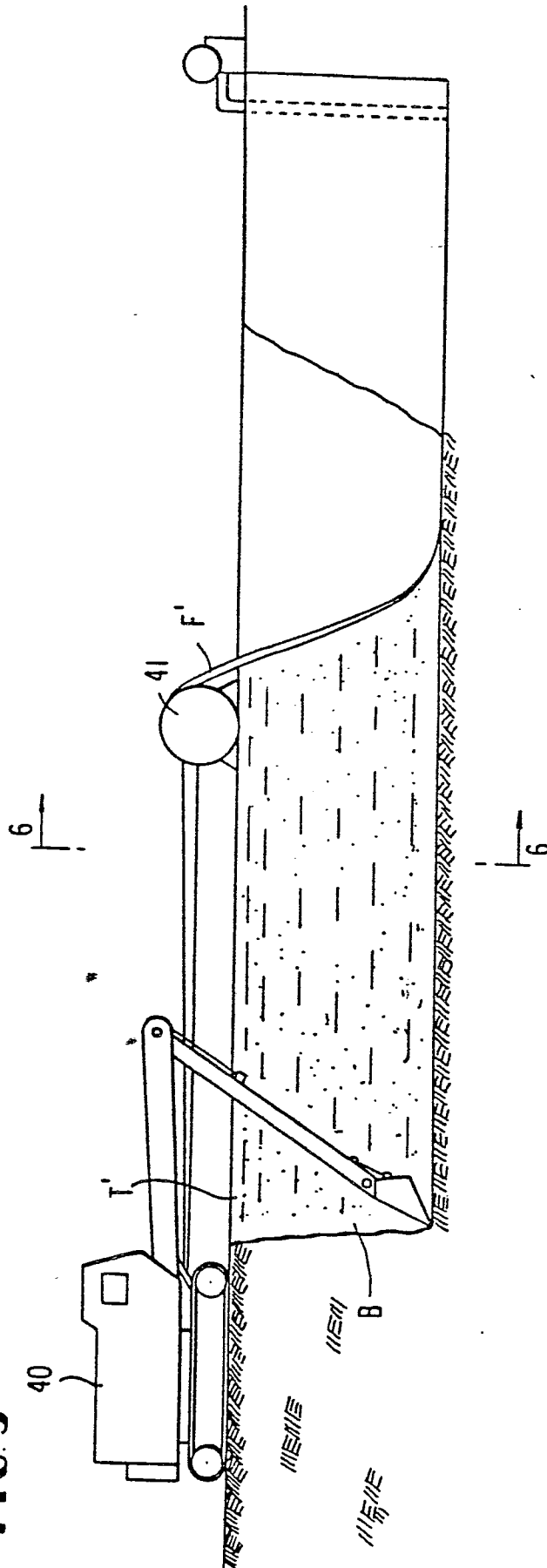
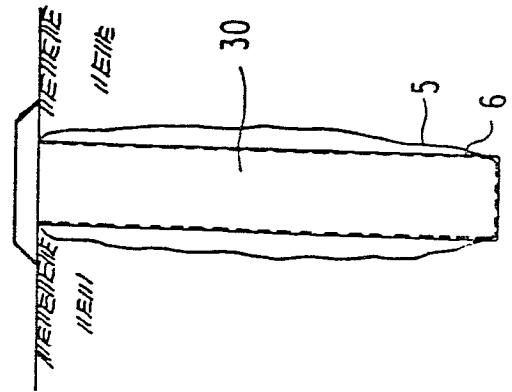


FIG. 6







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# EUROPEAN SEARCH REPORT

0062808

Application number

EP 82 10 2538

| 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. 3) |
| X   | FR-A-2 038 719 (BACHY)<br><br>*Page 1, lines 4-10,23-40; page 2, lines 1-2,16-25; page 3, lines 14-40; page 4, lines 1,11-13; page 5, lines 2-9; figure 8*   | 1,9,10<br>,11,12<br>,13,14   | E 02 D 5/18<br>E 02 D 19/18                    |
| X   | DE-A-2 546 946 (EUROSOND)<br><br>*Page 1; claim 1; page 2; claims 2 and 3; page 3; claim 7; page 4; claim 8; page 8, paragraph 2; page 12, paragraphs 1,2,3; page 13, paragraphs 1,2; page 14, paragraph 2; page 15, paragraph 2; page 19, paragraph 2; page 20, paragraph 4; figures 4,5,6* | 1,3,4,<br>8,9,10<br>,11,12<br>,14  |  |
| Y   | FR-A-2 094 290 (SOLETANCHE)<br><br>*Page 1, lines 26-32; page 2, lines 33-36; page 4, lines 2-8,32-40*   | 1,4,5,<br>10,11  | E 02 D   |
| Y   | DE-A-2 252 599 (HOFMAN UND MACULAN)<br><br>*Page 7, paragraph 6; page 8, paragraph 2; page 12, paragraph 2; page 13, paragraphs 2,3; figures 1,2*  | 1,4,7,<br>10,11,<br>12   |  |
| The present search report has been drawn up for all claims  |  |  |  |
| Place of search<br>THE HAGUE  |  | Date of completion of the search<br>25-06-1982   | Examiner<br>RUYMBEKE L.G.M.                    |
| CATEGORY OF CITED DOCUMENTS   |  | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |  |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |  |  |  |



| 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. 3) |
| A   | DE-A-1 634 517 (POLENSKY UND ZOLLNER)<br>*Page 1, paragraphs 1 and 4*         | 4, 5   |  |
| A   | DE-A-1 915 688 (VEB MANSFELD)   |  |  |
|   |   |  | TECHNICAL FIELDS SEARCHED (Int. Cl. 3)         |
|   |   |  |  |
| The present search report has been drawn up for all claims  |   |  |  |
| Place of search<br>THE HAGUE  |   | Date of completion of the search<br>25-06-1982   | Examiner<br>RUYMBEKE L.G.M.                    |
| <b>CATEGORY OF CITED DOCUMENTS</b>  |   |  |  |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |   | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |  |