(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 239 258 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **87301756.0**

(51) Int. Cl.⁴: **E 02 D 3/08**

(22) Date of filing: **27.02.87**

(30) Priority: **27.02.86 GB 8604823**

(43) Date of publication of application: **30.09.87 Bulletin 87/40**

(84) Designated Contracting States: **DE ES FR IT NL**

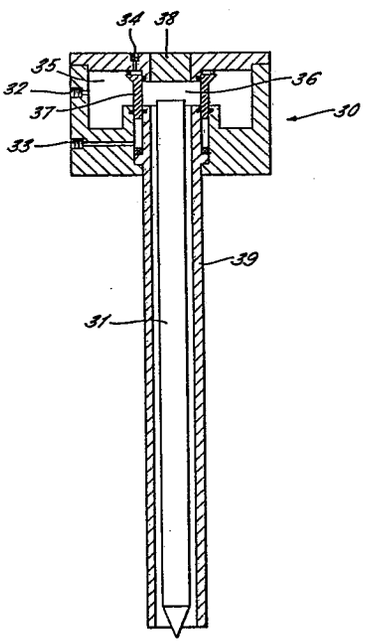
(71) Applicant: **UNIVERSITY COLLEGE CARDIFF CONSULTANTS LTD., P.O. Box 78, Cardiff, CF1 1XL (GB)**

(72) Inventor: **Bridle, Ronald, Parsonage Farm Kemys Commander, Usk Gwent NP5 1JU (GB)**

(74) Representative: **Mayes, Stuart David et al, BOULT, WADE & TENNANT 27 Furnival Street, London, EC4A 1PQ (GB)**

(54) Improvements in or relating to ground strengthening.

(57) Ground is strengthened by driving a number of pickets 31 into the ground from a launcher 30, sufficient momentum being imparted to the picket to enable it to penetrate and become embedded within the ground. The method can be used in sinking a cutting or raising an embankment in which the sinking or raising operation is split into stepped stages and rows of pickets used to reinforce the ground at each stage. Foundations may be strengthened by means of a reticular array of pickets. The launcher may be mounted on a vehicle. The ground surface may be covered with a cladding held in place by pickets having conically tapered or cylindrical heads.



EP 0 239 258 A1

IMPROVEMENTS IN OR RELATING TO GROUND STRENGTHENING

This invention relates to driving an elongate member into the ground and in particular, but not exclusively, to ground strengthening.

According to the present invention there is provided a method of driving an elongate member into the ground in which the member is fired from a launcher, sufficient momentum being imparted to the member to enable the member to thereafter penetrate and become embedded within the ground.

According to one aspect of the invention there is disclosed a method of ground strengthening wherein an elongate member comprising a picket is driven into the ground in accordance with the above disclosed method.

According to a further aspect of the invention there is disclosed a method of ground strengthening in which a plurality of pickets are driven into the ground to form an array of pickets.

According to a further aspect of the invention there is provided a method of sinking a cutting in the ground comprising the steps of driving a line of pickets into the ground so that the pickets extend at an angle to the vertical to one side of the line, excavating the ground to the other side of the line, driving a further line of pickets into the ground below the level of the first line so that the pickets extend at an angle to the vertical to the same side of the vertical as the first line, and repeating the steps of excavating and driving further lines of pickets into the ground until the cutting so formed is of a required depth, each picket being driven into the ground in accordance with the above disclosed method.

According to a still further aspect of the

invention there is provided a method of raising an embankment above the ground comprising the steps of driving a line of pickets into the ground so that the pickets extend at an angle to the vertical to one side of the line, raising the ground to that side of the line. driving a further line of pickets into the ground above the level of the first line so that the pickets extend at an angle to the vertical to the same side of the vertical as the first line, and repeating the steps of raising and driving further lines of pickets into the ground until the cutting so formed is of the required height, each picket being driven into the ground in accordance with the above disclosed method.

Preferably in such methods the pickets in each line are offset vertically from pickets in next higher and next lower lines of pickets.

Preferably each picket is fired into the ground by a gas gun which conveniently may be mounted on a vehicle and advantageously such a method of driving a line of pickets into the ground includes the steps of moving the vehicle along the bottom of the cutting or top of the embankment, as the case may be, and firing pickets into the ground one after another to form the line of pickets.

According to a further aspect there is disclosed a method of ground strengthening wherein the array of pickets comprises two or more sets, the pickets within each set being substantially parallel with one another and each set defining a different picket orientation such that in a projected view the pickets intersect in reticular fashion.

Surface cladding may conveniently be added to ground strengthened by the use of pickets and conveniently the cladding may be held in place by the pickets. Such cladding may include apertures through

each of which a respective picket is driven and wherein each picket includes a radially enlarged head of greater diameter than the respective aperture such that the picket is arrested by engagement of the head with the cladding.

This is particularly useful where the reinforced ground surface is vertical.

The picket may have a conically tapered head which is co-engageable in use with a conformally tapered seat of the surface cladding. The seat may be lined by a metallic shoe. Conveniently the cladding may be in the form of concrete slabs with a suitable array of apertures.

According to a further aspect of the present invention there is disclosed a picket for use in any such method and having a radially enlarged head. Similarly there is disclosed a surface cladding for use in such a method.

Further aspects of the invention other than those relating to ground strengthening are also disclosed hereafter.

According to such a further aspect of the invention relating to the placement of explosive charges in mining, excavation or the like the member may include an explosive charge so that the charge may be placed in an embedded position prior to detonation.

Alternatively in civil engineering or agricultural uses for example the member may be a drainage tube or may include ground conditioning material which is released to the surrounding ground after placement.

Alternatively the passage of the driven member through the ground may be used for placement of services such as cables and the like.

Such alternative aspects of the invention may

similarly include a method of firing the member into the ground by a gas gun which may be mounted on a vehicle.

In a preferred embodiment the gas gun is operated by compressed air.

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings of which:

Figures 1A to 1E are cross-sections through the ground illustrating various stages in the sinking of a cutting:

Figure 2 is a perspective view of the side wall of the cutting:

Figure 3 illustrates various stages in the raising of an embankment,

Figure 4 is a sectional view of a gas gun,

Figure 5 is a schematic sectional view of a site in which ground is reinforced with a reticular array of pickets,

Figure 6 is a similar view showing the way in which the group supporting a foundation tends to fail,

Figure 7 is a similar view taken in the direction 1 of Figure 5,

Figure 8 is a part section view of a picket having a tapered head which is received in an aperture having a tapered seat in a surface cladding, and

Figure 9 is a similar view of an alternative picket having a head of T shaped cross section received in an alternative surface cladding having a cylindrical aperture.

Referring to Figure 1, and in particular Figure 1A, in sinking a cutting firstly two lines of pickets 101,102 are fired into the ground each at an angle to the vertical so that the pickets extend downwardly and to the right of the line, as viewed in Figure 1A.

The ground to the left (as seen in Figure 1A) of the line of pickets 102 is then excavated to a depth equal to the desired vertical spacing of the lines of pickets which will strengthen the cutting wall. A further line of pickets 103 is then fired into the ground at the corner 10 between the bottom 12 of the excavation and the portion of the cutting wall 14 so far formed. The pickets 103 extend generally parallel to the pickets 101,102, as shown in Figure 1B.

The excavation and picket firing steps are then repeated so that the cutting is step-by-step made deeper as shown in Figures 1C and 1D, until the cutting is of the required depth, as illustrated in figure 1E. In the example shown in Figure 1E, the cutting wall is strengthened by the initial line of pickets 101 and a series of seven lines of pickets 102 to 108 at equally spaced levels along the cutting wall 14. Finally, a further line of pickets 109 is forced into the bottom 12 of the cutting adjacent the corner 10 with the cutting wall 14.

The pickets in adjacent lines are preferably offset as shown in Figure 2 and as designated by dashed lines in Figure 1.

A similar method is used to strengthen the opposite wall of the cutting as excavation proceeds.

Figure 3 illustrates a method of raising an embankment, which is somewhat similar to the cutting sinking method described above. Referring to Figure 3A, firstly two lines of pickets 201,202 are fired into the ground so that they extend downwardly and to the right of the line as viewed in Figure 2A.

The ground above the pickets 202 and to the right thereof, as seen in Figure 3A, is then raised to a height equal to the desired vertical spacing of the lines of the pickets and a further line of pickets 203 is then fired into edge 16 formed by the top 18 and wall 20 of the embankment raised so far.

The raising and picket firing steps are then repeated until the embankment is of the desired height, and then a further line of pickets 209 are fired into the top 22 of the embankment adjacent the edge 16 between the top and side wall 20 of the embankment.

Figure 4 illustrates a gas gun 30 in which an elongate member 31 is loaded. The gas gun shown is operated by compressed air received through air lines (not shown) connected to ports 32,33 and 34. An inlet port 32 admits compressed air to an annular reservoir 35 separated from a chamber 36 of the gun by a cylindrical valve member 37.

The chamber is closed by a breech 38 through which the elongate member 31 is loaded. Air admitted through a firing port 34 actuates the valve member 37 which moves downwards as shown in the drawing to release air from the reservoir (35) to the chamber 36 whereupon the elongate member 31 is fired from the barrel 39. A reset port 33 admits air to return the valve member 37 after firing.

Figure 5 illustrates an application of ground stengthening at a site in which ground 300 lies between a wall 301 having a foundation 302 and a

cutting 303 for pipe work 304. A reticular array of pickets 305 is formed by firing two sets of pickets 306 and 307 from a launcher such that each set forms a parallel array defining a different picket orientation such that in a projected view the pickets intersect in reticular fashion. In this example the sets of pickets also intersect in reticular fashion when viewed in projection in a second direction at right angles to the first as shown in Figure 7.

This sytem of ground strengthening may also be termed root piling since the driven pickets may be likened to roots.

The way in which the ground supporting a foundation fails under load is illustrated in Figure 6 in which a wall 308 is supported on a foundation 309. The wedge of earth 310 immediately beneath the foundation is driven downwards putting the adjacent wedges 311 into plastic deformation so that the surrounding zone of earth 312 shears out of the ground in the direction arrowed. The foundation therefore fails at critical failure surfaces shown in the drawing as dashed lines and in strengthening the ground surrounding such a foundation a reticular array of pickets crossing the critical failure surfaces increases the bearing capacity of the foundation. Such strengthening is readily achieved in accordance with the present invention by firing the pickets from a launcher.

Figure 7 shows an alternative picket 400 having a radially enlarged head 401 which is conically tapered in the direction in which the picket is driven in use. A surface cladding layer 402 of concrete is shown applied to an embankment 403 and the cladding layer includes an aperture 404 comprising a tapered seat lined with a metallic shoe 405. In use the picket is driven through the

aperture 404 and penetrates the embankment 403 until the head 401 encounters the shoe 405. The picket 400 is then arrested. In this position the head 401 is positioned in a predetermined manner relative to the surface cladding layer 402.

Figure 9 shows an alternative picket 406 which has a head 407 which is not tapered but has a cylindrical form such that the end of the picket is of T shaped cross section. The picket is shown received in an aperture 408 in a surface cladding layer 409. The head 407 functions to arrest the picket 406 such that the head is in contact with the surface cladding layer 409 and the penetration of the picket 406 is controlled to a pre-determined depth.

Surface cladding layers 402, 409 may be applied to embankments or other surface areas where pickets are to be used for ground strengthening and such layers are typically provided with a regular array of apertures corresponding to the required pattern of driven pickets.

The use of pickets 400, 406 having radially enlarged heads 401, 407 serves a dual purpose of controlling the depth of penetration of the picket and of retaining surface cladding 402, 409 in position.

The pickets used in any of the above examples could be of metallic material or of other material such as plastics.

CLAIMS

1. A method of driving an elongate member 31 into the ground characterised in that the member is fired from a launcher 30, sufficient momentum being imparted to the member to enable the member to thereafter penetrate and become embedded within the ground.

2. A method of ground strengthening characterised in that an elongate member comprising a picket 31 is driven into the ground in accordance with the method of Claim 1.

3. A method of ground strengthening as claimed in Claim 2 characterised in that a plurality of pickets are driven into the ground to form an array 101 to 109 of pickets.

4. A method of sinking a strengthened cutting in the ground characterised by comprising the steps of driving a line of pickets 102 into the ground so that the pickets extend at an angle to the vertical to one side of the line, excavating the ground to the other side of the line, driving a further line of pickets 103 into the ground below the level of the first line so that the pickets extend at an angle to the vertical to the same side of the vertical as the first line, and repeating the steps of excavating and driving further lines of pickets 104 to 109 into the ground until the cutting so formed is of a required depth, each picket being driven into the ground in accordance with the method of Claim 1.

5. A method of raising a strengthened embankment above the ground characterised by

comprising the steps of driving a line of pickets 202 into the ground so that the pickets extend at an angle to the vertical to one side of the line, raising the ground to that side of the line, driving a further line of pickets 203 into the ground above the level of the first line so that the pickets extend at an angle to the vertical to the same side of the vertical as the first line, and repeating the steps of raising and driving further lines of pickets 204 to 209 into the ground until the cutting so formed is of the required height, each picket being driven into the ground in accordance with the method of Claim 1.

6. A method as claimed in Claim 4 or 5, characterised in that the pickets in each line are offset vertically from pickets in next higher and next lower lines of pickets.

7. A method as claimed in any of Claims 2 to 6, characterised in that each picket is fired into the ground by a gas gun 30.

8. A method as claimed in Claim 7, characterised in that the gas gun is mounted on a vehicle.

9. A method as claimed in Claim 8 when dependent on Claim 4 or 5, characterised in that the step of driving a line of pickets into the ground includes the steps of moving the vehicle along the bottom of the cutting or top of the embankment, as the case may be, and firing pickets into the ground one after another to form the line of pickets.

10. A method as claimed in claim 3

characterised in that the array of pickets comprises two or more sets 306, 307, the pickets within each set being substantially parallel with one another and each set defining a different picket orientation such that in a projected view the pickets intersect in reticular fashion.

11. A method as claimed in any of claims 3 to 10 characterised by including the further step of adding surface cladding 402, 409.

12. A method as claimed in claim 11 characterised in that the cladding is held in place by pickets 400, 406.

13. A method as claimed in claim 11 or 12 characterised in that the surface cladding includes apertures 408 through each of which a respective picket is driven and wherein each picket includes a radially enlarged head 401, 407 of greater diameter than the respective aperture such that the picket is arrested by engagement of the head with the cladding.

14. A method as claimed in any of claims 12 to 13 characterised in that the reinforced ground surface is vertical.

15. A picket for use in the method of claim 13 and characterised by having a radially enlarged head 401, 407.

16. A picket as claimed in claim 15 characterised by comprising a conically tapered head 401 which is co-engageable in use with a conformally tapered seat 405 of the surface cladding.

17. A surface cladding for use in the method as claimed in claims 11 to 14.

18. A method as claimed in Claim 1 characterised in that the member is a drainage tube.

19. A method as claimed in Claim 1 characterised in that the member includes an explosive charge so that the charge may be placed in an embedded position prior to detonation.

20. A method as claimed in Claim 1 characterised in that the member includes ground conditioning material which is released to the surrounding ground after placement.

21. A method as claimed in Claim 1 characterised in that the passage of the driven member through the ground is used for the placement of services such as cables and the like.

22. A method as claimed in any of Claims 16 to 19 characterised in that the member is fired into the ground by a gas gun.

23. A method as claimed in Claim 20 characterised in that the gas gun is mounted on a vehicle.

FIG. 1A.

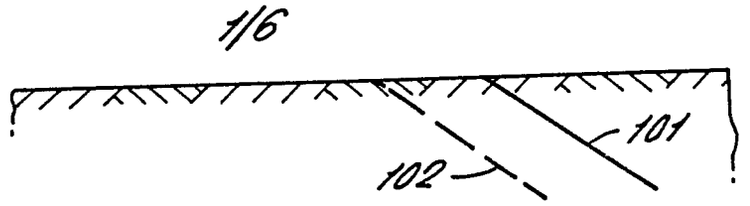


FIG. 1B.

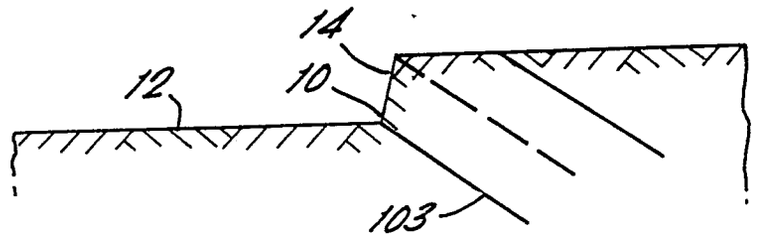


FIG. 1C.

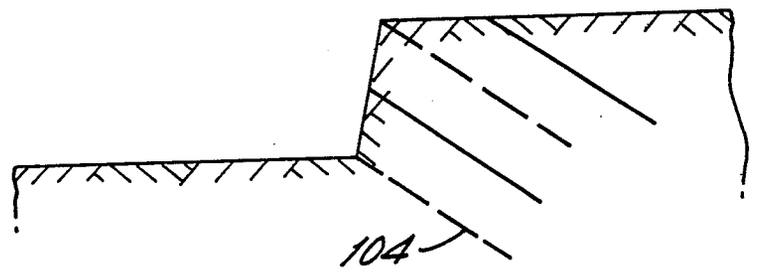


FIG. 1D.

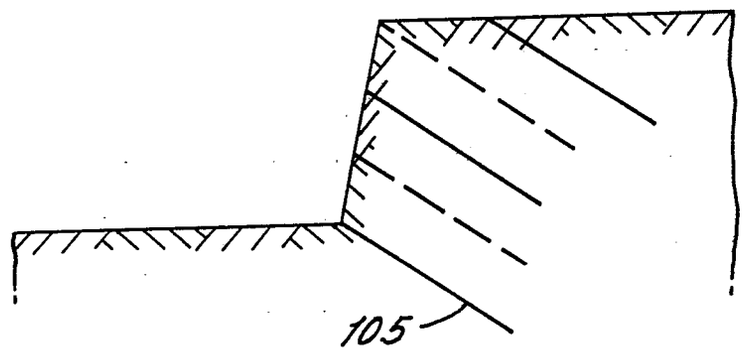


FIG. 1E.

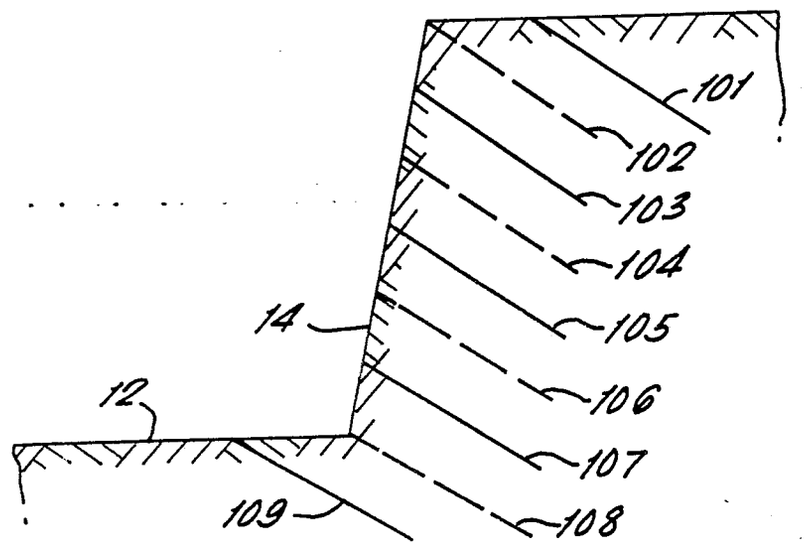


FIG. 2.

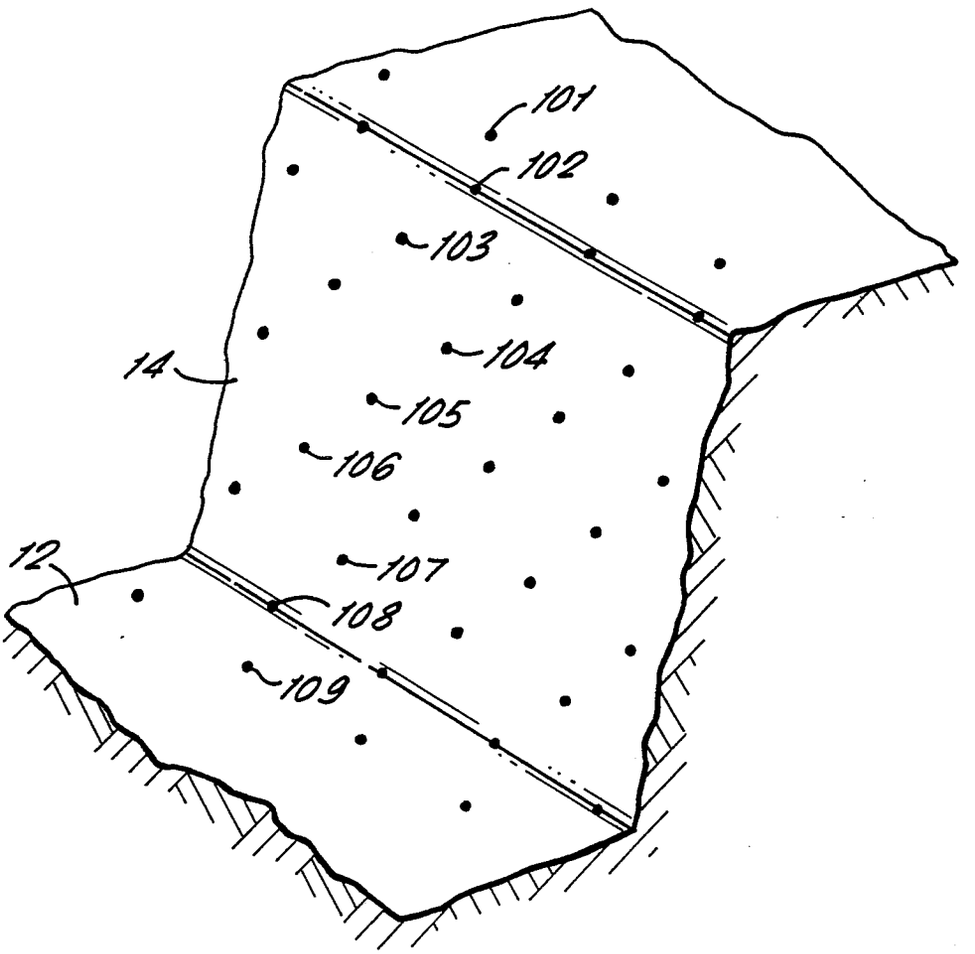


FIG. 3A.

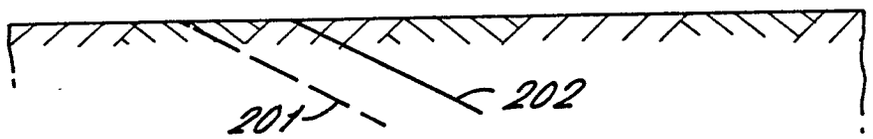


FIG. 3B.

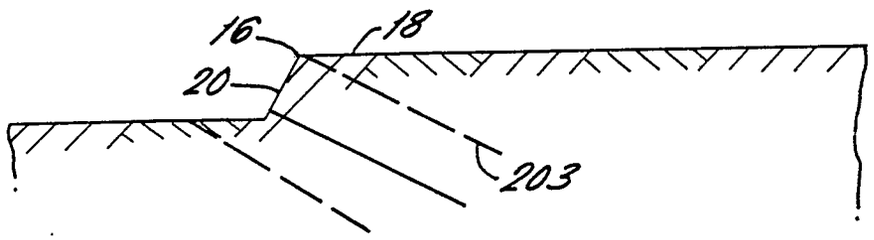


FIG. 3C.

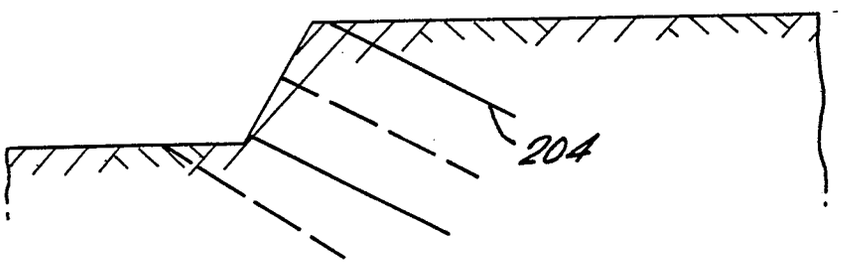


FIG. 3D.

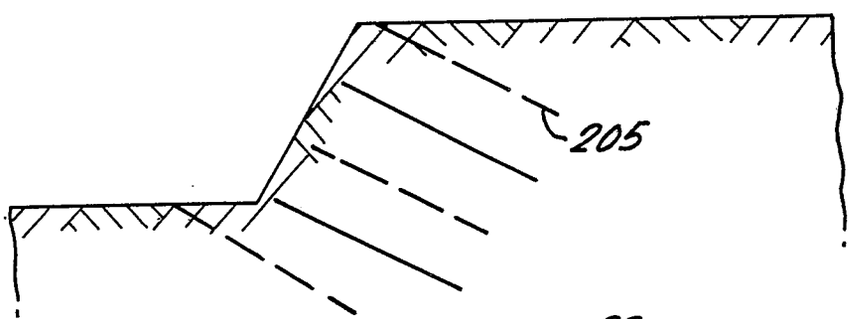


FIG. 3E.

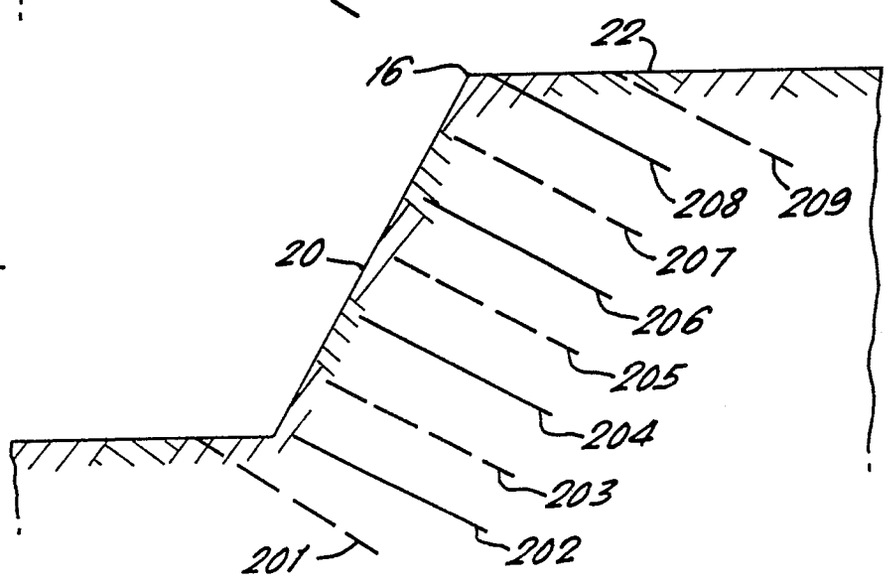


FIG. 4.

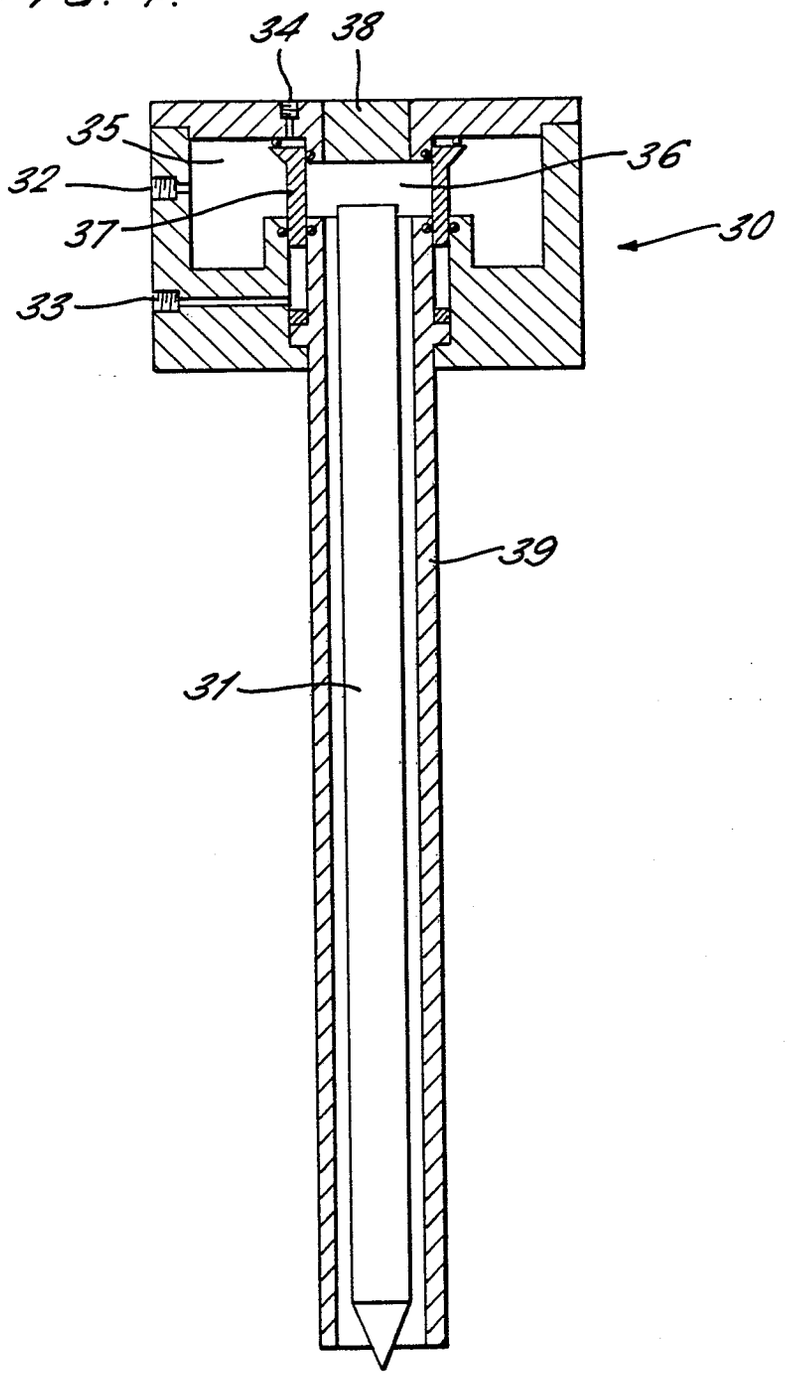


FIG. 5.

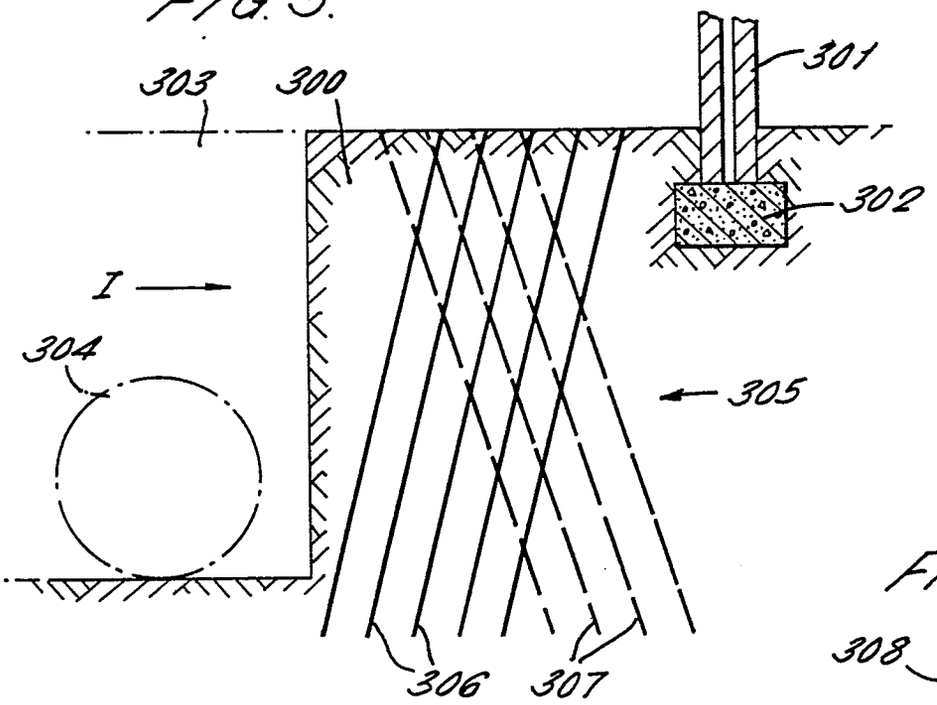


FIG. 6.

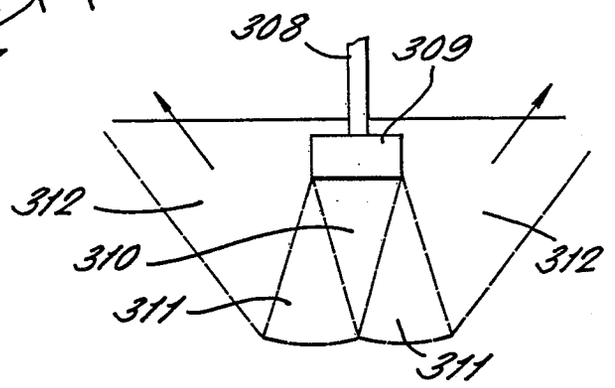
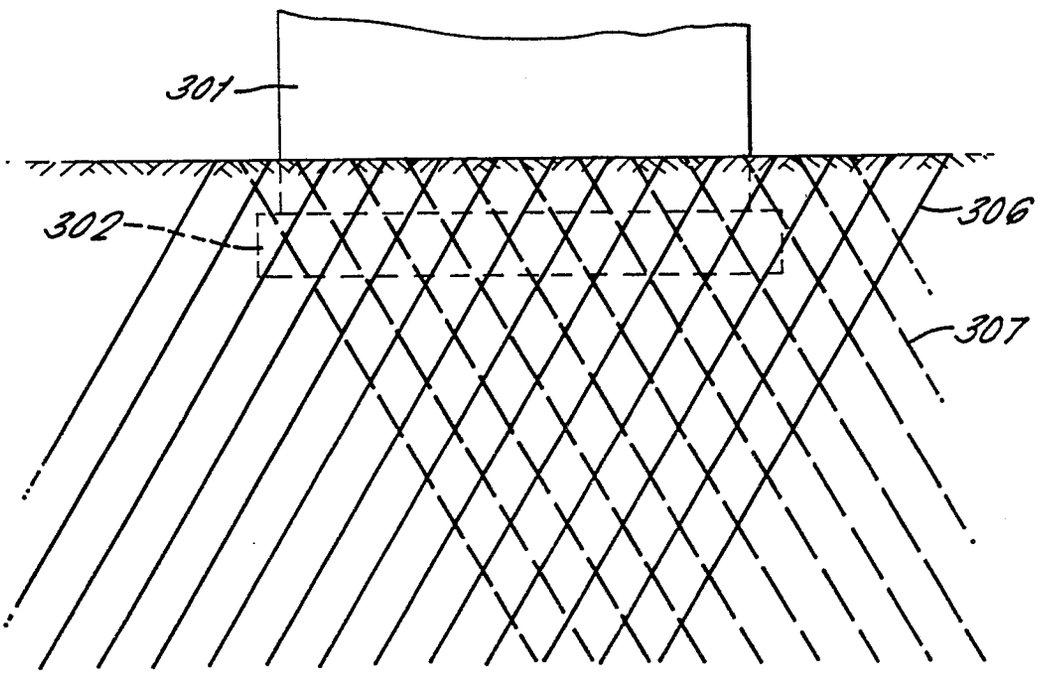


FIG. 7.



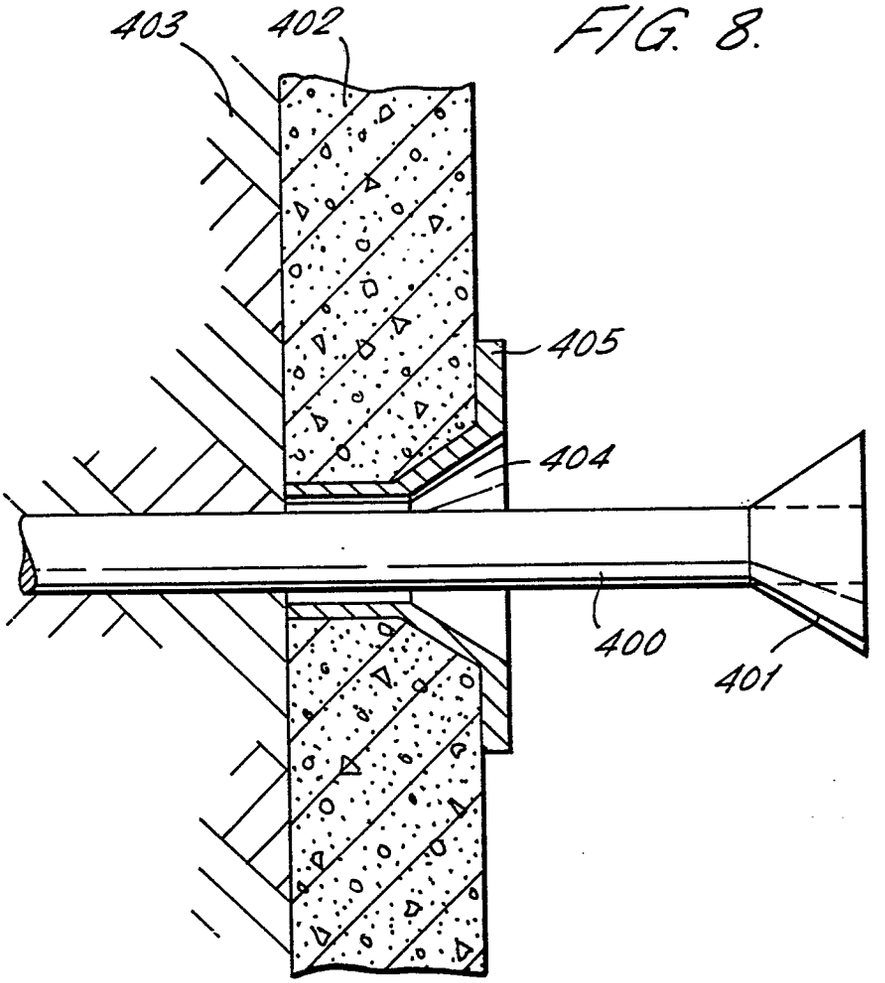


FIG. 8.

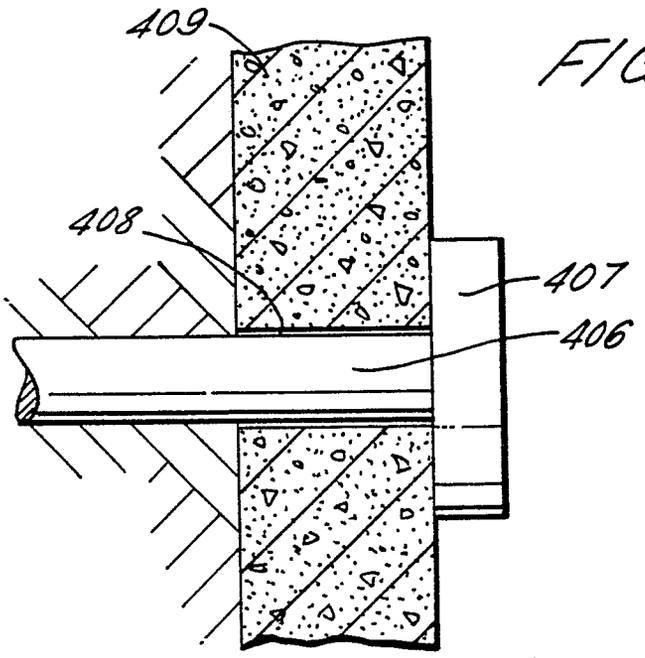


FIG. 9.

0239258

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 30 1756

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.4)
X	EP-A-0 039 654 (TRAVOCEAN) * Page 6, line 22 - page 8, line 22; page 9, line 15 - page 14, line 23; figures 1-4,10,11 *	1,19, 20	E 02 D 3/08
Y		2-4,6, 11-13, 15	
A		23	

X	GB-A-2 058 182 (RANDALL) * Page 1, lines 38-45; page 1, line 118 - page 3, line 33; figures 1-7 *	1	
A		7,22	TECHNICAL FIELDS SEARCHED (Int. Cl.4) E 02 D E 04 H B 27 F

Y	DE-A-2 631 745 (BAUER) * Page 3, lines 1-21; page 3, line 25 - page 4, line 9; page 6, lines 16-28 *	2,3,11 -13,15	
A		18,20	
	--- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-07-1987	KERGUENO J.P.D.

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

EPO Form 1503 03 82

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 30 1756

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.4)
A	US-A-3 802 204 (MASON) * Column 1, lines 30-40; column 2, line 33 - column 3, line 29; column 4, line 36 - column 5, line 32; figures 3,7-14 *	4,6	
A	---	11-14	
A	FR-A-2 313 506 (BRAMI) * Page 1, lines 8-28; page 2, line 15 - page 3, line 20; figures 1-4 *	4,10, 11,14, 15,20	
A	---		
A	DE-A-1 528 159 (BENOZZI)		
	---		TECHNICAL FIELDS SEARCHED (Int. Cl.4)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-07-1987	KERGUENO J.P.D.

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

EPO Form 1503 03.82