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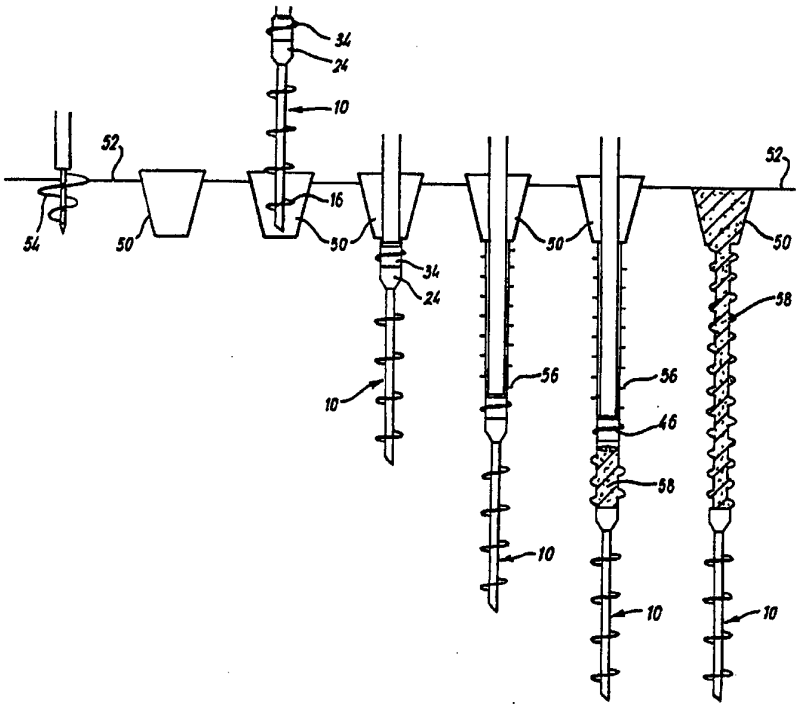

(57) Abstract

Apparatus for use in forming a pile, said apparatus comprising an elongate member (10), a helical flight (16) on the elongate member (10) and transmission means (24) to transmit torque to the elongate member and flight. The apparatus can be inserted into the ground by torque applied through said transmission means (24) to form, or form part of, the pile.

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IMPROVEMENTS IN OR RELATING TO APPARATUS FOR USE IN FORMING PILES

This invention relates to apparatus for use in forming piles.

Conventional methods for driving piles, or pile formers, into the ground, comprise either hammering the pile or pile former, or vibrating the pile or pile former, into the ground.

The disadvantages of such techniques are that damage can be caused to nearby buildings by the hammering, or the vibration, particularly if the buildings are old and unstable. Additionally the techniques are noisy.

It is an object of this invention to obviate and/or mitigate this disadvantage.

According to one aspect of this invention there is provided apparatus for use in forming a pile, said apparatus comprising an elongate member, a helical flight on the elongate member and transmission means to transmit torque to the elongate member and flight whereby the apparatus can be inserted into the ground by torque applied through said transmission means to form or form part of the pile.

Preferably, the transmission means is of greater diameter than the elongate member whereby as the elongate member is inserted into the ground, the transmission means is pulled downwardly through the ground by the elongate member, thus creating a hole in the ground which is of substantially the same width as the transmission means.

Preferably, the elongate member has a first flight arranged towards its free end and a second flight spaced from the first flight. Advantageously, the second flight is so arranged on said elongate member that it follows substantially the path of the first flight when said elongate member is inserted into the ground. Further intermediate flights may be provided between the first and second flight.

Preferably a removable connecting member connects the transmission means to the torque applying means.

One or more elongate extension members are fixable between the connecting member and the torque applying means.

Preferably, the transmission means is open topped, includes an outer cylinder surrounding an end of the elongate member and having an end converging towards

said elongate member and a diametrically extending drive bar.

Preferably the elongate member is a steel tube, the free end of which is closed or flattened into a spade formation. Preferably the transmission means is welded to the elongate member at the smaller end of the converging portion.

Preferably the connecting member has an outer diameter substantially equal to that of the transmission means and a projecting spigot for insertion into the transmission means, said spigot having a longitudinally extending surface thereon to engage the drive bar to transmit torque to the elongate member and helical flight(s).

Preferably two diametrically opposed longitudinally extending surfaces are provided each having an inclined surface leading thereto such that when the direction of torque application is reversed the connecting member disconnects from the transmission means.

Preferably a further helical flight is formed on the outer surface of the connecting member. Said further helical flight preferably extends for a full

revolution, is of a diameter less than the first, second and intermediate flights, but of the same pitch. Alternatively the flights may be of substantially the same diameter.

Preferably the said extension members are hollow.

The or each extension member is also provided with appropriate connecting formations to connect one end of the or each extension member to, or a further extension member.

Preferably, the connecting formations are in the form of threads.

Preferably the or each extension member has apertures formed in its walls.

Preferably means are provided at or near ground level to contain a mass of unset cementitious material through which said extension member extends whereby said material may fill and maintain open the hole and helical grooves behind the transmission member.

In one embodiment, the cementitious material is pumped into the hole, preferably via a bore through the elongate member. The bore may extend through the

connecting member.

In another embodiment, a single helical flight is provided on the elongate member and further flights are provided on the extension member.

Preferably, the transmission means is fixed to the lower end of the extension member.

Preferably, a cylindrical recess is provided in the base of the transmission means to receive the top portion of the elongate member, said member having a radially extending drive bar engageable against drive faces defined by the part of the transmission means defining the recess.

Preferably, inclined surfaces lead from said drive faces so that on reversing the direction of rotation of the apparatus from the drive direction the elongate member becomes detached and separate from the transmission means.

According to another aspect of the invention there is provided a method of forming a pile comprising applying torque by torque applying means to an elongate member having a helical flight thereon to insert the elongate member into the ground, the torque being

applied thereto by an assembly including extension means connectible between torque applying means and a transmission means which is wider than the extension means and connects the extension means with the elongate member, whereby when the elongate member is inserted into the ground the tranmission means is pulled through the ground behind it thereby forming a hole in the ground which is of substantially the same width as the transmission means and less than the width of the extension means and filling said hole with pile forming material.

Preferably prior to inserting said elongate member and helical flight into the ground a depression is formed in the ground for reception of the elongate member and helical member. The depression is downwardly converging with its upper diameter is greater than the outer diameter of the helical flight and its lower diameter less than the outer diameter of the helical flight.

Preferably the depression is formed by driving a conical mandrel into the ground from ground level. Alternatively the depression is formed by means of an auger or other suitable soil removal means.

Preferably the hole is filled with pile forming

material either during or after the elongate member, transmission means and extension means are inserted. When the hole is filled during the insertion of the elongate member, transmission means and extension means, a mass of pile forming material is maintained in the depression.

Preferably after the elongate member has been inserted into the ground to a desired depth, the extension means are disconnected therefrom and removed by applying torque thereto in the direction opposite to the insertion direction.

Preferably an un-set cementitious material is supplied down the extension member during removal to fill the hole beneath the elongate member before it sets. Reinforcement may be placed in the unset cementitious material.

An embodiment of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a partially sectioned side elevation of apparatus for use in forming a pile,

Fig. 2 shows a view from below,

Fig. 3 shows a view from above,

Fig. 4 shows a side elevation, to an enlarged scale, of a connecting member on the end of an extension member.

Fig. 5 shows a bottom plan view of the connecting member,

Fig. 6 shows a sectional elevation of the connecting and extension members,

Fig. 7 illustrates the disconnection of the connection and extension members from the pile forming member,

Fig. 8 shows the sequence of operations followed during a pile forming operation,

Fig. 9 shows a side elevation similar to Fig. 1 of yet another embodiment,

Fig. 10 shows part of the embodiment shown in Fig. 9. and

Fig. 11 shows a side elevation similar to Fig. 1 of a still further embodiment.

Referring in the first instance to Fig. 1 there is shown apparatus for forming a pile and comprising an

elongate hollow steel tubular member 12 to which is attached by welding a first helical thread flight 16 near the lower end thereof, a second helical thread flight 18 near the upper end thereof and two further intermediate thread flights 20, all of the said flights having the same pitch, flight angle and diameter so that as the member is rotated into the ground the first flight pulls the member into the ground without displacing the ground in the manner, for example, of a wood screw. The intermediate and second flights follow the first flight in the helical channel formed in the ground by the first flight.

The lower end of the member 12 is sealed at 22 and a transmission means 24 is provided at the upper end. The transmission means comprises an open ended cylindrical sleeve 26 having a first conical converging portion 28 at its lower end, the portion 28 merging into the elongate member 12 and being fixed thereto by welding at 30. A diametrically extending steel bar 32 is provided and extends across the interior of the sleeve 26 and through the open end region of the elongate member 12.

The apparatus is inserted into the ground by applying a downward loading thereon and a torque applied in a clock-wise direction. It is inserted into the

ground by the thread flights 16,18,20 and as these flights all have the same diameter, pitch and angle, flights 20 and 18 will follow the path of the first thread flight 16.

Figs. 4,5 and 6 show the means for applying torque by transmission from a surface mounted rotating drive member. A connection member 34 having an outside diameter substantially equal to the outside diameter of the transmission means is welded to the end of a tubular steel extension member 36 which, at its upper end, has engagement means 38 for engaging with the driving mechanism.

A spigot 40 extends from the lower end of the connecting member 34 and is provided with two diametrically opposed longitudinally extending drive faces 42 which, when the spigot is inserted into the tranmission means are adapted to abut the drive bar 32 and transmit rotation of the connecting member to the transmission means. An inclined surface 44 leads into the drive faces 42 and it will be observed that when the extension and connecting member 36,34 are driven in a clockwise direction with a downward force supplied thereto the surfaces 42 will engage the bar 32, but when the connecting and extension member are driven in an anti-clockwise direction the inclined surfaces will ride

up over the bar 32 and cause disconnection of the driving means from the transmission means.

A helical flight 46 is welded to the outer surface of the connecting member 34. The flight has a diameter less than the first, second and intermediate flights 16,18,20 but has the same pitch and angle. Alternatively, the flights are of substantially the same diameter. The flight is formed of two outer sections, 48 and an inner section 50 therebetween. Each section is of substantially the same thickness.

To form a pile the first step is to form a downwardly converging frusto-conical depression 50 at ground level 52. This can be done by utilising a conical soil removing auger 54 but if the ground conditions are not suitable for forming a depression by such means then a frusto-conical mandrel can be driven or vibrated into the ground to form the depression 50.

The pile forming member 10 is then introduced into the depression 50 and it will be noted from Fig. 8 that the smallest diameter of the depression is substantially equal to or smaller than the diameter of the first flight 16. By applying torque a downward force member 10 is driven into the ground and it is to be appreciated that as it is inserted it drags the

transmission means and connecting member 24,34 behind it creating a circular hole, the diameter of which is greater than the diameter of the extension member 36, so that the frictional forces from the ground resisting the insertion of the pile forming member are confined at all stages of the driving operation and after full penetration of the pile forming member to those experienced by the pile forming member 10 and connecting member 34.

Thus, generally, the frictional resistance forces during the driving operation are constant irrespective of the depth of the pile because effectively no frictional resistance is experienced by the extension member 36. This significantly reduces the power required to drive piles when compared with a normal pile driving operation where the greater the depth of the pile, the greater the frictional forces to be overcome.

When the pile has been driven to a pre-calculated depth, the direction of rotation of the drive means is reversed and an upward force applied to the extension and connecting members 36,34. This causes separation of the extension and connection members from the pile driving forming 10 comprising the transmission means, elongate member 12 and helical flights 16,18,20 which remain at the bottom of the pile hole, that is they are sacrificed.

The helical flight 46 on the connecting member 34 occupies the helical groove 56 formed in the ground during descent and effectively seals off the bottom of the hole left by the retreating connecting member so that cementitious material 58, for example grout or concrete, supplied down the extension member fills the hole behind the retreating connection and extension members,the hole being kept clear of debris by the ascending connection member and the helical flight thereon. Alternatively, grout or concrete is supplied to the depresssion during the entire pile hole forming operation and flows into the hole behind the retreating extension member via a bore extending through the connecting member 34. During this operation a hydrostatic head is maintained by the unset cementitious material, or water or any other suitable fluid maintained in the depression 50.

Prior to the cementitious material setting reinforcing bars can be inserted into the fully filled hole and depression. If desirable, the bars are mechanically connected with the pile forming member 10 remaining down the hole by means of, for example, a bayonet connection with the drive bar 32.

Figs. 9 and 10 show a modification of the embodiment illustrated in the earlier figures. It will be appreciated that the embodiment shown in Figs.1 to 8, the pile forming member remaining down the hole is

relatively expensive and the modification shown in Figs. 9 and 10 provides a less expensive arrangement whereby all but the lower end of the tubular member 12 and one thread flight remain down the hole.

Fig. 10 illustrates the member which is left down the hole. It can be seen to comprise a relatively short hollow steel tubular member 112 to which is attached by welding a first helical thread flight 116. At the lower end the tubular member 112 is closed off in a chisel shape 122 and near the upper end there is provided a drive bar 132 extending through the tube and projecting radially from each side thereof.

In this modification the extension member 136 carries the second and intermediate thread flights 118 and 120 and fixed to the bottom end of the connecting member 136 by welding is the transmission means 124, the outside diameter of which is greater than the outside diameter of the extension member 136 but less than the external diameter of the helical thread flights 116,118,120. A cylindrical recess 130 is formed in the base of a transmission means 124 and receives the upper end 134 of the member 112. Extending from the recess 130 and defined by the transmission means 124 are driving faces 142 to engage the drive bar 122, the faces 142 being connected to inclined surfaces (not shown) such that drive can be transmitted to the member 112 in

the manner described above with reference to Figs.4, 5 and 6 and, on reversing the direction of rotation of the extension member 136 the member 112 can be disconnected from the transmission means 124.

As in the earlier embodiments the connection member 134 has an upper cylindrical section 126 and a lower frusto-conical section 128.

It will be realised therefore that the modification illustrated in Figs. 9 and 10 is utilised in the same manner as the embodiment described with reference to Figs. 1 - 8.

Similar comments regarding mode of operation apply to the modification illustrated in Fig.11 where only the tip 160 is left down the hole.

In the modification the extension member 136 has an elongate hexagonal cross-section tapering end portion 162 forming the elongate and transmission member permanently fixed to its lower end. Second and intermediate thread flights 118, 120 are welded to the extension member 136 and end portion 162 as before and the end portion carries also the first helical thread flight 116.

The sacrificial tip 160 is also of hexagonal cross-section and is a push fit on the end of the end portion

162 so that when the direction of rotation is reversed to withdraw the extension member and end portion the tip 160 remains down the hole formed during the operation.

Cementitious material, for example, grout fed down the extension member will exit into the formed pile hole through the now open end of the tapering end portion 162 and also through a port 164 near the upper end of the end portion 162. The port 164 is equipped with a closure 166 which keeps the port closed until a suitable mechanism opens it when the direction of rotation is reversed.

In a further modification where the head room in which the pile insertion apparatus has to operate is limited, the extension member 136 can comprise a plurality of interconnectable sections such that its length can be built up as it progesses down the hole.

In a further modification where the the extension member can remain down the hole after the hole forming operation to provide the reinforcement. In this modification unset micro concrete is supplied down the extension members and enters the hole at the connection member A suitable supply of micro concrete is provided to ensure that the hole behind the connecting member and the depression is full to overflowing and the overflowing unset micro concrete is collected from the depression and recycled to concrete mixer and pump which supplies the micro concrete to the extension members.

CLAIMS

1. Apparatus for use in forming a pile, characterised in that it comprises an elongate member (12,112), a helical flight (116,118,120) on the elongate member(12,112) and transmission means (24,124) to transmit torque to the elongate member and flight, whereby the apparatus can be inserted into the ground by torque applied through said transmission means to form or form part of the pile.

2. Apparatus as claimed in claim 1, characterised in that the transmission means (24,124) is of greater diameter than the elongate member (12,112) whereby as the elongate member is inserted into the ground, the transmission means is pulled downwardly through the ground by the elongate member, thus creating a hole in the ground which is of substantially the same width as the transmission means.

3. Apparatus as claimed in claim 1 or claim 2, characterised in that the elongate member (12) has a first flight (16) arranged towards its free end (22) and a second flight (18) spaced from the first flight.

4. Apparatus as claimed in claim 3, characterised in that the second flight (18) is so arranged on said elongate member (12) that it follows substantially the

path of the first flight (16) when said elongate member is inserted into the ground.

5. Apparatus as claimed in claim 4, characterised in that intermediate flights (20) are provided between the first (16) and second flight (18).

6. Apparatus as claimed in any one of the preceding claims, characterised in that a removable connecting member (34,134) connects the transmission means (24,124) to the torque applying means.

7. Apparatus as claimed in claim 6, characterised in that one or more extension members (36,136) are fixable between the connecting members (34,134) and the torque applying means.

8. Apparatus as claimed in any one of the preceding claims, characterised in that the transmission means (34 134) is open topped, includes an outer cylinder (26,126) surrounding an end of the elongate member (12,112) and has an end (28,128) converging towards said elongate member and a diametrically extending drive bar (32,132).

9. Apparatus as claimed in any one of the preceding claims, characterised in that the elongate member (12,112) is a steel tube, the free end (22,122) of which is closed or flattened into a spade formation.

10. Apparatus as claimed in claim 8 or claim 9, characterised in that the transmission means (24,124) is welded to the elongate member (12,112) at the smaller end of the converging portion (28,128).

11. Apparatus as claimed in any of claims 6 to 10, characterised in that the connecting member (34) has an outer diameter substantially equal to that of the transmission means (24) and a projecting spigot (40) for insertion into the transmission means, said spigot having a longitudinally extending surface (42) thereon to engage the drive bar (32) to transmit torque to the elongate member (12) and helical flight(s).

12. Apparatus as claimed in claim 11, characterised in that two diametrically opposed longitudinally extending surfaces (42) are provided each having an inclined surface (44) leading thereto such that when the direction of torque application is reversed the connecting member (36) disconnects from the transmission means (34).

13. Apparatus as claimed in any one of claims 6 to 12, characterised in that a further helical flight (50) is formed on the outer surface of the connecting member.

14. Apparatus as claimed in claim 13, characterised in that said further helical flight (50) extends for a full revolution is of a diameter less than the first, second

and intermediate flights (16,18,20) and of the same pitch.

15. Apparatus as claimed in any one of claims 7 to 14, characterised in that the said extension members (36,136) are hollow.

16. Apparatus as claimed in claim 15, characterised in that the or each extension member (36,136) is also provided with appropriate connecting formations to connect one end of the or each extension member to, or a further extension member.

17. Apparatus as claimed in claim 16, characterised in that the connecting formations are in the form of threads.

18. Apparatus as claimed in claim 16 or claim 17, characterised in that the or each extension member has apertures formed in its walls.

19. Apparatus as claimed in any one of the preceded claims, characterised in that means (50) are provided at or near ground level to contain a mass of unset cementitious material (52) through which said extension member extends whereby said material may fill and maintain open the hole and helical grooves behind the transmission member.

20. Apparatus as claimed in any one of claims 7 to 10 and 14 to 18, characterised in that a single helical flight (116) is provided on the elongate member (112) and further flights (118,120) are provided on the extension member (136).

21. Apparatus as claimed in claim 20, characterised in that the transmission means (124) is fixed to the lower end of the extension member (136).

22. Apparatus as claimed in claim 21, characterised in that cylindrical recess (130) is provided in the base of the tranmission means (124) to receive the top portion of the elongate member (112), said member having a radially extending drive bar (122) engageable against drive faces (142) defined by the part of the transmission means (124) defining the recess.

23. Apparatus as claimed in claim 22, characterised in that inclined surfaces lead from said drive faces (142) so that on reversing the direction of rotation of the apparatus from the drive direction the elongate member (112) becomes detached and separates from the transmission means (124).

24. Apparatus as claimed in any one of claims 1 to 5 characterised in that the elongate member and transmission means are provided by a single end portion (162)

fixed to the end of an extension member (136) for rotation therewith and carrying helical flights (116,120) said portion (162) tapering downwardly and having a removable end cap (160).

25. Apparatus as claimed in claims 24, characterised in that the end portion (162) has a hollow hexagonal cross-section and a port (164) which is closed when the portion is being driven into a hole and open when it is being removed.

26. A method of forming a pile comprising applying torque by torque applying means to an elongate member having a helical flight thereon to insert the elongate member into the ground, characterised in that the torque is applied thereto by an assembly including extension means (36,136) connectible between torque applying means and a transmission means (24,124) which is wider than the extension means and connects the extension means with the elongate member (12,112), whereby when the elongate member (12,112) is inserted into the ground the transmission means (24,124) is pulled through the ground behind it thereby forming a hole in the ground which is of substantially the same width as the transmission means and less than the width of the extension means and filling said hole with pile forming material.

27. A method as claimed in claim 26, characterised in

that prior to inserting said elongate member and helical flight into the ground a depression (50) is formed in the ground for reception of the elongate member (12,112) and helical member (16,116).

28. A method as claimed in claim 27, characterised in that the depression (50) is downwardly converging with its upper diameter is greater than the outer diameter of the helical flight (16,116) and its lower diameter less than the outer diameter of the helical flight (16,116).

29. A method as claimed in claim 27 or claim 28, characterised in that the depression (50) is formed by driving a conical mandrel into the ground from ground level.

30. A method as claimed in claim 27 or claim 28, characterised in that the depression (50) is formed by means of an auger (54) or other suitable soil removal means.

31. A method as claimed in any one of claims 26 to 30, characterised in that the hole is filled with pile forming material either during or after the elongate member (12,112), transmission means (24,124) and extension means (36,136) are inserted.

32. A method according to claim 31, characterised in that the hole is filled during the insertion of the elongate member (12,112), transmission means (24,124)

and extension means (36,136), by a mass of pile forming material maintained in the depression (50).

33. A method as claimed in any one of claims 26 to 32, characterised in that after the elongate member (12,112) has been inserted into the ground to a desired depth, the extension means (36,136) are disconnected therefrom and removed by applying torque thereto in the direction opposite to the insertion direction.

34. A method as claimed in any one of claims 26 to 32, characterised in that after the elongate member (12,112) has been inserted into the ground to a desired depth, the extension means (36,136) are retained down the hole as the pile forming material sets.

35. A method as claimed in any one of claims 26 to 31, characterised in that an un-set cementitious material is supplied down the extension member (12,112) during removal to fill the hole beneath the elongate member before it sets.

36. A method as claimed in claim 35, characterised in that reinforcement is placed in the un-set cementitious material.

37. A method as claimed in any one of claims 26 to 36, characterised in that a vertical load is applied to the elongate member (12,112) as it forms the pile hole.

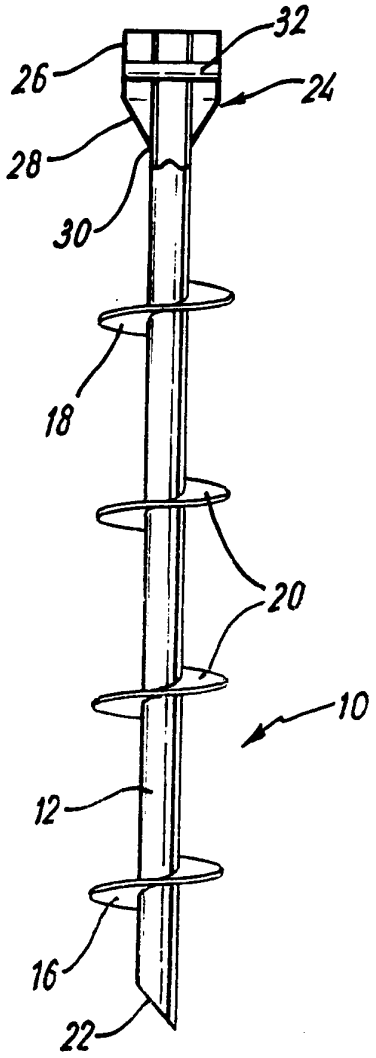


FIG.1

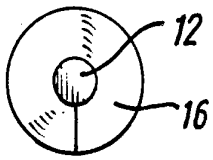


FIG.2

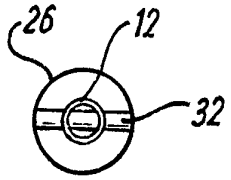
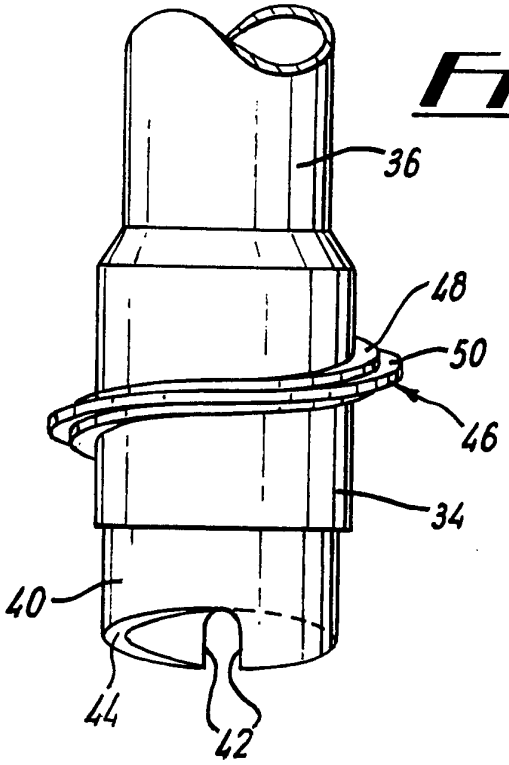


FIG.3

FIG.4



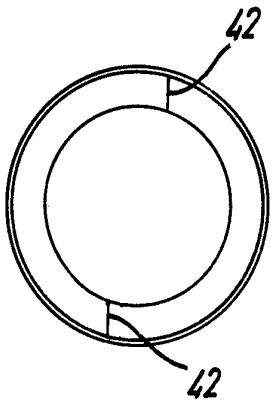
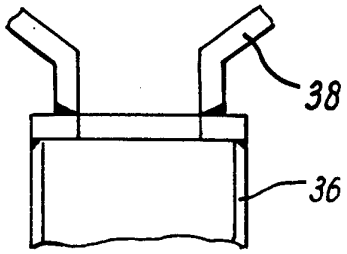


FIG.5



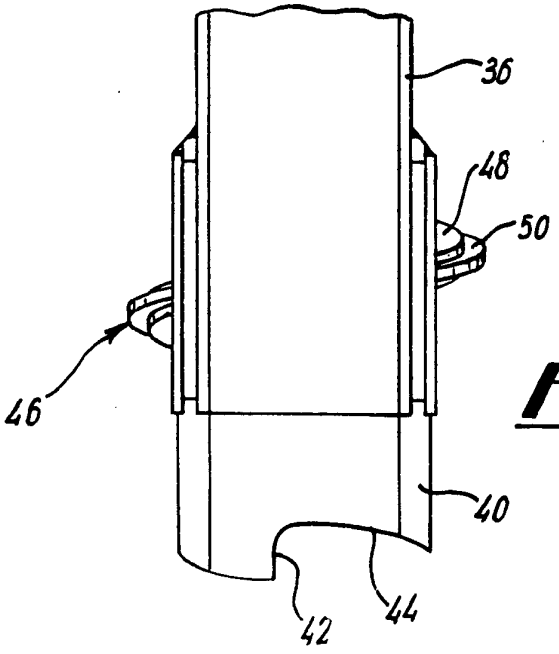


FIG.6

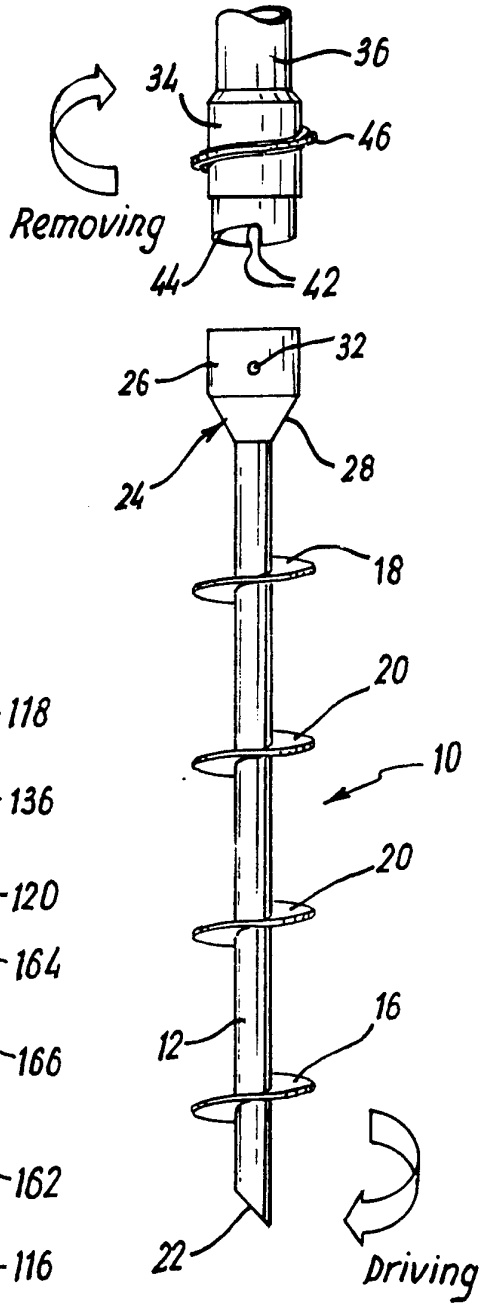


FIG. 7

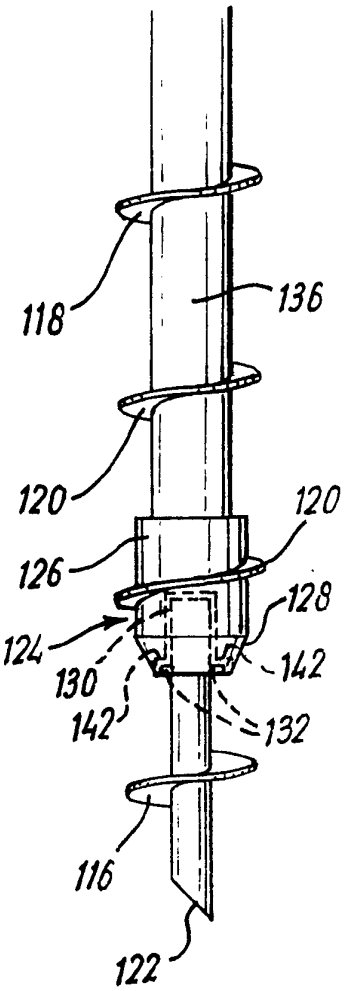


FIG. 9

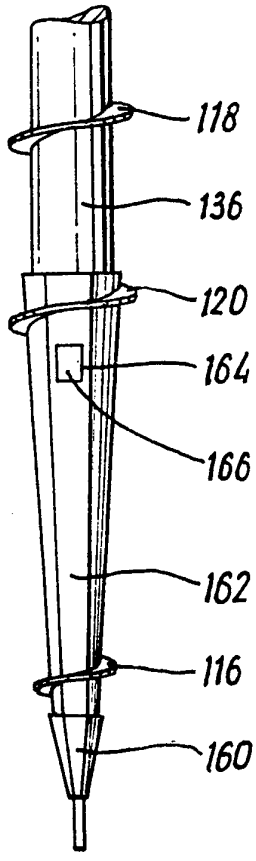


FIG. 11

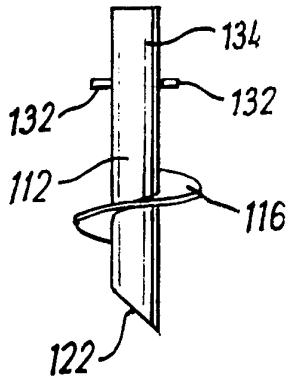


FIG. 10

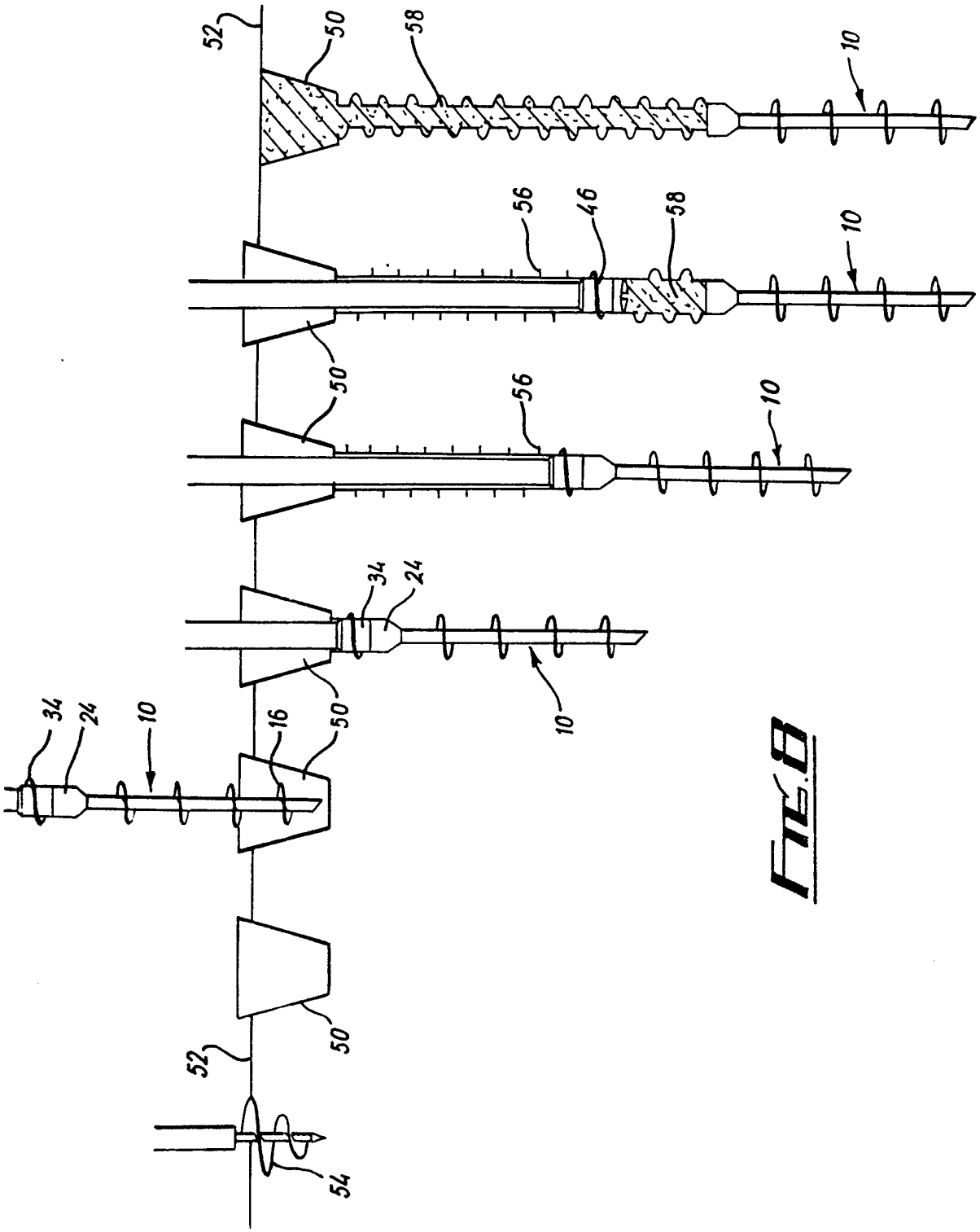


Fig.8

INTERNATIONAL SEARCH REPORT

Internat 1 Application No
PCT/GB 95/00010

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E02D5/38 E02D7/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NL,A,7 712 013 (WILLIAM F GILLEN JR) 5 May 1978	1,6
Y	see page 3, line 4 - page 5, line 22	3-5,8,9, 11,12, 15,19
A	see page 6, line 25 - page 13, line 28; figures 1-12	2,13,16, 24-26

Y	NL,A,7 608 927 (FUNDEX PVBA) 14 February 1978	3-5
A	see the whole document	20

Y	DE,C,523 177 (SIEMENS-BAUUNION G.M.B.H. K.G.) 20 April 1931	8,11,12, 15
A	see the whole document	16, 21-23,33

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 April 1995	25. 04. 95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blommaert, S

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Interna l Application No
PCT/GB 95/00010

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	see page 8, right column, line 25 - page 9, right column, line 31; figures 14,15	1
Y	FR,A,2 180 405 (STEDING) 23 November 1973	19
A	see claims; figures	27,29, 31,32,37
A	DE,A,29 49 938 (BBC BROWN BOVERI & CIE) 19 June 1981 see page 10, line 13 - page 13, line 13; figure 1	8,10,15, 16,21, 22,33
A	DE,A,22 06 104 (RAYMOND INTERNATIONAL INC.) 28 September 1972 see page 6, line 13 - page 11, line 2; figures	27,29, 31,35-37
A	DE,B,10 97 373 (ALLARD) 12 January 1961	
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