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E21B 10/32

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E1F FCJ

(56) Documents Cited:
GB 2372056 A **GB 2222621 A**
GB 1596308 A **GB 1102682 A**

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UK CL (Edition V) **E1F, E1H**
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Other: **EPODOC, WPI, JAPIO**

(54) Abstract Title: **Underreamer for making piles**

(57) An underreamer for making a pile has at least two arms (30, 32) formed from a number of sections (36, 37, 38) connected together in series. Each arm (30, 32) is pivotally mounted to upper and lower supports (34, 39), such that each arm (30, 32) is drivable between a retracted and extended position, the two arms (30, 32) projecting laterally outwardly in the extended position. By pivotally mounting the arms (30, 32) at both ends, the arms (30, 32) are linked so that they extend outwardly in their middles when extended. The arms (30, 32) may be provided with cutting teeth and the first and second sections (36) of the arms may be either straight or curved.

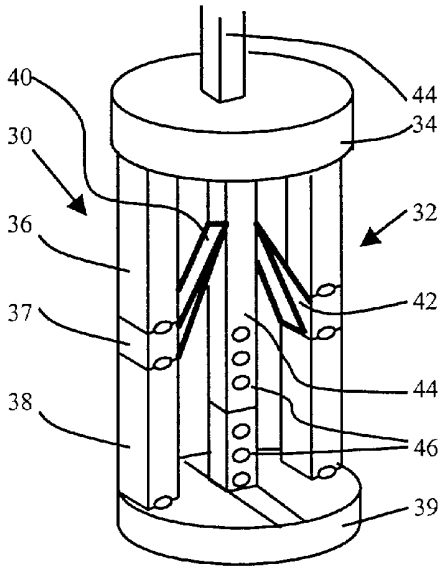

FIG. 2

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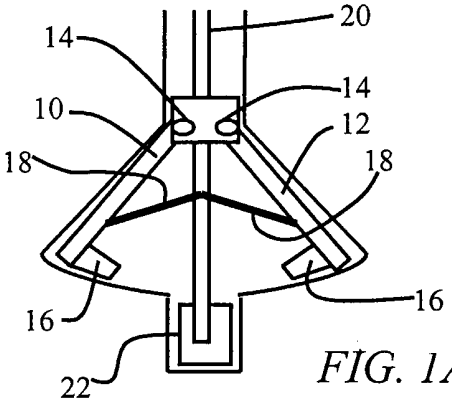

FIG. 1A

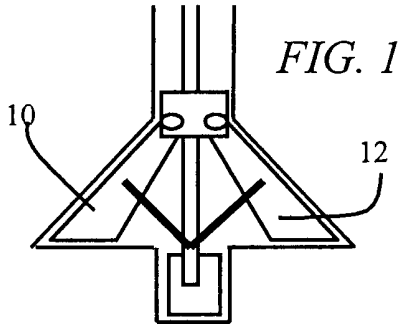

FIG. 1C

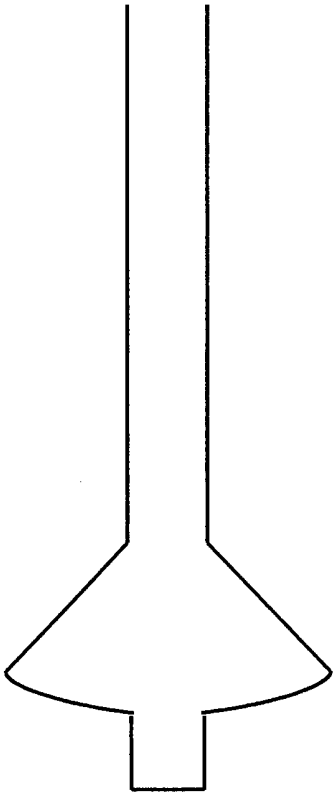

FIG. 1B

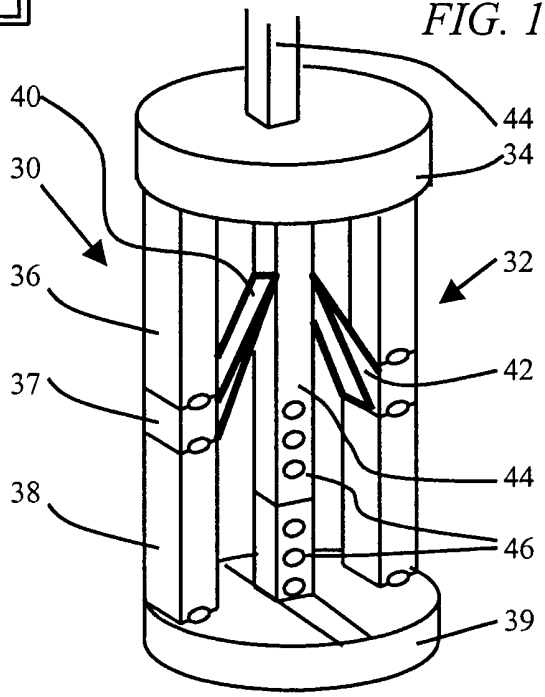

FIG. 2

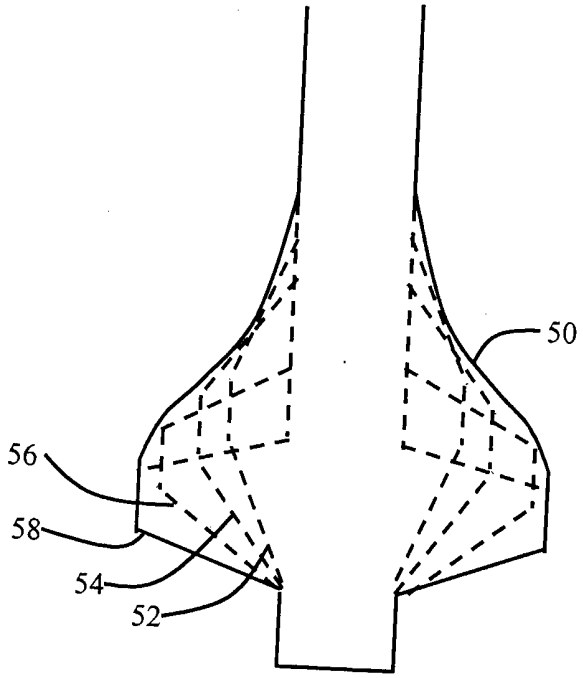

FIG. 3

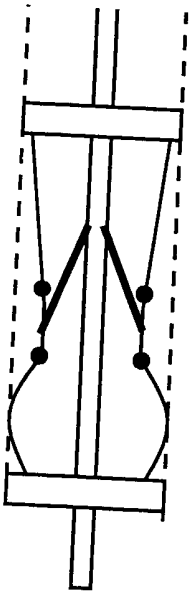

FIG. 4

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A PILING DEVICE

This invention relates to piling, and in particular the formation of under-reamed piles.

Large diameter bored piles have been used in the construction industry in increasing volume since the late 1960s. Piles are constructed by digging to the required depth using an auger of between one and three metres in length, in a series of incremental steps. The clean auger is lowered down the advancing pile borehole to the base where it is rotated into the soil. Once the auger is fully 'loaded' with spoil, it is removed from the hole and the auger cleaned before re-insertion into the pile bore.

In some cases, it is desirable to form a pile with an enlarged base, known as an "under-ream". The base of the pile provides the primary load bearing part of the pile, and an expanded base enables the pile to support a greater load, without needing to increase the pile diameter over the full height of the pile. Typically, approximately half of the cost of a pile is for the concrete, and an under-reamed pile provides more efficient use of the volume of concrete.

Various under-reaming systems are known for forming piles with an enlarged base. Typically, the pile is initially bored to the required depth in conventional manner, for example using an auger as mentioned above. The bore is typically drilled incrementally, with the soil removed in stages.

An under-reaming tool is attached to the bottom of the drilling bar. This tool has a number of blades which can be driven between a compressed state, in which they fit within the envelope of the initial bore, to an expanded state in which they are rotated to enlarge the base of the bore. The most common types of under-reaming tool are so-called "top-hinge" mechanisms and so-called "centre-hinged" mechanisms. In each case, the base of the pile is enlarged in a series of incremental steps, each increasing the diameter of the under-reamed base at its lowest level.

In a top-hinged arrangement, the base of the under-ream has a part-spherical shape which is swept clean by so-called "scraper blades" during the under-reaming operation. These scraper blades remain in contact with the base during the operation and are intended to maintain a clean base once the equipment is removed from the bore. In a centre-hinged arrangement, the blades follow a more complicated path, and

a flat base can be formed. However, the base is not swept clean by this arrangement, and some manual cleaning is therefore required (as discussed further below).

The excavated material is caught in a bucket beneath the blades. The under-reaming tool is removed from the bore, and the bucket emptied, between the incremental steps.

Various problems are encountered in these under-reaming operations. When the under-reaming tool is removed, some soil (or other excavated material) can fall from the freshly worked surface into the base of the bore. When the under-reaming tool is then lowered into position, it may adopt a slightly different position, so that it is difficult to control accurately the alignment during successive under-reaming steps.

One feature of the top-hinge mechanism is that under-reams formed in this way undergo continual re-working (also referred to as re-moulding) of the soil at the base of the finished under-ream. This re-working of the soil at the base of the under-ream is of concern to design engineers who consider that the re-working of soils weakens them and thus reduces the finished load bearing capacity of the pile. In particular, if the base of the pile is contaminated with loose debris or an interface of reduced strength as a result of the re-working of the soil, this will influence the settling properties of the pile. The ability to predict differential settling characteristics between different piles supporting a common structure is critically important. This feature of under-reams has been known and accepted for a number of years, and is taken into account in the design of the pile.

Until the mid 1990's it was common practise to descend a worker into a pile upon completion of the formation of the under-ream, in order to remove loosened/re-worked soils to improve the end-bearing capacity. This practise involved labour-intensive and time-consuming manned descent of the borehole and manual cleaning of the pile base. After this period, new safety legislation has made manned-descent of unlined boreholes even more undesirable and the practise has been largely abandoned.

In its place, piling contractors have attempted to improve construction protocols, and in some cases have devised remotely operated instruments to determine the condition of the soils at the base of the under-ream, presumably to demonstrate the effectiveness or otherwise of the cleaning protocol. However, these measuring devices provide at best a rough indication of the strength of the soil and at worst a confusing result. Designers have thus tended to disregard these results and assume

that the pile base has been wholly or partially disturbed, reducing the end-bearing capacity at the design stage in anticipation.

Conversely, it has been recognised that it would be desirable to ensure that the last of the cyclic digging operations performed on the base of an under-ream is deeper than all the previous cycles, as this would ensure that little or no re-moulded soil is present. This is difficult to achieve with conventional top-hinge under-reaming devices.

According to the invention, there is provided a piling device for forming an under-ream at the base of a pile, comprising at least first and second arms extending longitudinally between an upper support and a lower support, each arm comprising at least two sections pivotally connected together in series, and each arm being pivotally mounted to the upper and lower supports, such that each arm is drivable between a retracted and an extended position, the two sections projecting laterally outwardly in the extended position.

By pivotally mounting the arms at both ends, the arms are linked so that they extend outwardly in their middles when extended. As the arms are driven incrementally towards their fully extended positions, any soil which is re-worked is in the middle of the excavated area rather than at the base. Thus, the re-moulding of soil on the base of under-ream piles is avoided.

The device may have only first and second arms, opposite each other. This provides a balanced arrangement for rotation.

Each arm can comprise only two sections, so the arms extend outwardly in a "V" configuration. However, each arm may comprise first, second and third sections, the three sections being connected in series with the third section between the first and second sections, the third section being shorter than the first and second sections. The third section can then form a deeper side-wall section to the under-ream.

The two sections of each arm are preferably each provided with cutting teeth.

Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

Figures 1A to 1C show known top-hinged and centre-hinged under-reaming devices and the shape of an under-reamed pile formed using the top-hinged under-reaming arrangement;

Figure 2 shows a first example of piling device of the invention;

Figure 3 is used to explain the operation of the device of the invention and shows the shape of the formed under-ream; and

Figure 4 shows a second example of piling device of the invention.

Figure 1A shows the most commonly used under-reaming arrangement. The under-reaming device has two diametrically opposed arms 10, 12 which are hinged at the top (hinge points 14). Each arm has a scraper blade 16, and the arms are incrementally driven to the fully extended position shown in Figure 1A by the drive arms 18. The arms 10, 12 are rotated about the shaft 20, and during the under-reaming operation, the scraper blades 16 clean the base surface of the under-ream.

The excavated material is caught in a bucket 22. This bucket may have a cutting face at its base and may then rotate with the shaft 20, or else the bucket may remain stationary.

As shown more clearly detail in Figure 1B, the top-hinged arrangement provides an under-ream with a spherical base.

Figure 1C shows schematically the centre-hinged arrangement, which provides a flat base, a shown. The top-hinged arrangement is preferred as it provides a self cleaning operation. However, as discussed above, the repeated reworking of the soil at the base of the under-ream is now recognised as a significant drawback of the top-hinged arrangement.

The gradual formation of the under-ream incrementally from the bottom and sides outwards gives rise to the re-moulding problem, as the digging tool continually passes over the same piece of soil, especially near to the centre of the under-ream.

Figure 2 shows an under-ream tool of the invention. The tool again has first and second arms 30, 32 extending longitudinally between an upper support 34 and a lower support 39. A collection bucket, not shown in Figure 2, is provided beneath the lower support 39, and may be integral with it. Each arm 30, 32 has at least two sections pivotally connected together in series. In the example of Figure 2, each arm has three sections 36, 37, 38. Each arm is pivotally mounted to the upper and lower supports, to be drivable between a retracted position (as shown in Figure 2) and an extended position. In the retracted position, the arms fit within the envelope of the initial constant diameter bore. In the extended position, the centre sections 37 are driven outwardly

Although not shown in Figure 2, the sections 36, 37, 38 are provided with cutting teeth, as is conventional..

By pivotally mounting the arms 30, 32 at both ends, the arms are linked so that they extend outwardly in their middles. As the arms are driven incrementally towards their fully extended positions, a new portion of the base of the under-ream is excavated at each incremental step. The re-moulding of soil on the base of under-ream piles is thereby avoided.

The drive mechanism for extending the arms 30, 32 will operate in the same way as for existing under-ream devices, and will not therefore be described in detail. As shown schematically in Figure 2, control arms 40, 42 extend between a central shaft 44 and the central arm sections 37. The central shaft 44 is linearly shifted to extend the arms outwardly, and a latch arrangement 46 can be used to limit the overall lateral expansion of the arm 36, 37, 38 into a number of predetermined positions.

Figure 3 shows the shape 50 of the under-reamed pile formed using the tool of the invention. The profiles shown as 52, 54, 56 and 58 represent the incremental positions of the arms, for the three-section arrangement of Figure 2.

The device opens the top and sides of the under-ream first, and in so doing works its way gradually towards the base of the under-ream. The final base of the under-ream is not formed until the last movement of the under-ream tool.

As shown, the resulting under-reamed pile has a flat base (assuming a straight bottom section 38 as shown in Figure 2), and the angle of inclination can be selected by controlling the extent to which the arms are extended. It is widely accepted that a slope of 35 degrees or more is self-cleaning, in that loose debris will fall down the slope. If the pile is under-reamed to this angle, the base of the under-ream will be largely self-cleaning and there is also little or no remoulding of the soil at the base. This can thus avoid the need for manual cleaning of the base of the under-ream and also avoids the need for monitoring of the quality of the surface.

The use of a straight top section 36 gives a radiused roof profile. This may be beneficial in soils of borderline stability.

Although the arm sections are straight in the example above, it is equally possible to provide curved arm sections. Figure 4 shows in simplified form an arrangement with curved bottom sections. This arrangement can be used to form a base with a more traditional profile, if desired, although the self-cleaning properties are not as good.

It is equally possible to provide radiused top arms, so that tool can be used to form a straighter profile to the roof of the under-ream, in line with more traditional roof profiles.

During the under-reaming operation, the steep sides of the under-ream in its early stages mean that the excavation is effectively self-cleaning – whereby the excavated soil will fall into the collection bucket, rather than being drawn into the collection bucket by the action of the scraper blades of a traditional tool. With sufficient capacity in the collection bucket, this will decrease the length of time to excavate a given volume of soil at the base and in addition reduce the number of cycles required to excavate the full under-ream. This will have an additional cost benefit and will be welcomed in soil types where self-stability of the soil is of limited duration.

Thus, the device of the invention can enable a reduced overall excavation time, and can avoid the need for base testing regimes that are required for other methods. This reduced excavation time improves soil stability, which is time dependant, as well as providing general cost and time benefits.

The form of the tool described above has a three-section arm on either side. Another obvious variation has a two-piece arm on either side. In practice each arm, may have more than three section, and indeed there may be more than two arms. Each variation in number of arm sections and shape of arm sections can bring added features to the finished profile of the excavated under-ream. The desired excavated profile can easily be obtained through appropriate shape and arrangement of arm sections.

When two arms are used, the final excavation operation can simply involve a 180 degree rotation, so as to avoid any overworking of the base of the under-ream.

The pile formed using the tool of the invention may have a variety of depths and diameters. By way of example, the diameter of the initial bore may typically be around 1m – 2.5m, and the under-ream may occupy a height of around 2m - 5m at a depth of around 20m – 40m. The diameter of the under-ream is typically around two to three times the diameter of the initial bore, although with this device, there is no practical limit to the multiples of pile shaft diameter to which the under-ream may be enlarged.

Various other modifications will be apparent to those skilled in the art.

Claims

1. A piling device for forming an under-ream at the base of a pile, comprising at least first and second arms extending longitudinally between an upper support and a lower support, each arm comprising at least two sections pivotally connected together in series, and each arm being pivotally mounted to the upper and lower supports, such that each arm is drivable between a retracted and an extended position, the two sections projecting laterally outwardly in the extended position.

2. A device as claimed in claim 1, comprising only first and second arms.

3. A device as claimed in any preceding claim, wherein each arm comprises only two sections.

4. A device as claimed in claim 1 or 2, wherein each arm comprises first, second and third sections, the three sections being connected in series with the third section between the first and second sections, the third section being shorter than the first and second sections.

5. A device as claimed in any preceding claim, wherein the at least two sections of each arm are each provided with cutting teeth.

6. A device as claimed in any preceding claim, wherein the first and second sections are straight.

7. A device as claimed in any one of claims 1 to 5, wherein the first and second sections are curved.

INVESTOR IN PEOPLE

Application No:	GB 0224658.5	**Examiner:**	Dr. Lyndon Ellis
Claims searched:	1-7	**Date of search:**	9 January 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X Y	1-3, 6 4, 5	GB 2372056 A	(Cementation) Whole document
X Y	1-3, 6 4, 5	GB 2222621 A	(Cementation) Whole document
X Y	1-4, 6 4	GB 1102682	(Gosudarstvenny) Whole document, noting three piece arm in fig 1
X Y	1-3, 5,6 5	GB 1596308	(Weaver) Whole document, noting cutting teeth on the arms in fig 1

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

E1F, E1H

Worldwide search of patent documents classified in the following areas of the IPC[7]:

E21B, E02D

The following online and other databases have been used in the preparation of this search report:

Online: EPODOC, WPI, JAPIO