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None

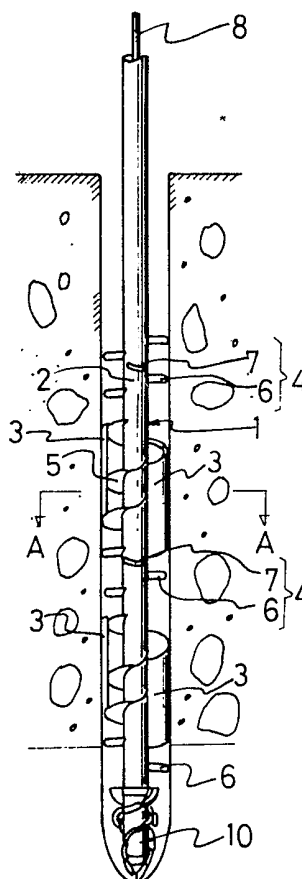
(58) Field of search

E1H

(54) Method and apparatus for pile construction

(57) A method for pile construction utilizes an auger, to excavate the pile hole to a depth of supporting stratum, which comprises a rod 1 supporting sealing vanes 3 which are spaced from the peripheral surface of the rod 1 and circumferentially curved. Agitating vanes 4, 4' project from said peripheral surface of the rod 1, and a cutter head 10 is mounted at the lower end of the rod 1. In use the sealing vanes 3 operate to pack the excavated material after agitation by the vanes 4, 4' against the wall of the hole, thereby sealing the wall. The auger is withdrawn with positive rotation thereof, and a prefabricated or cast-in-situ pile is then erected in the hole.

Fig. 1(A)



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Fig. 1(A)

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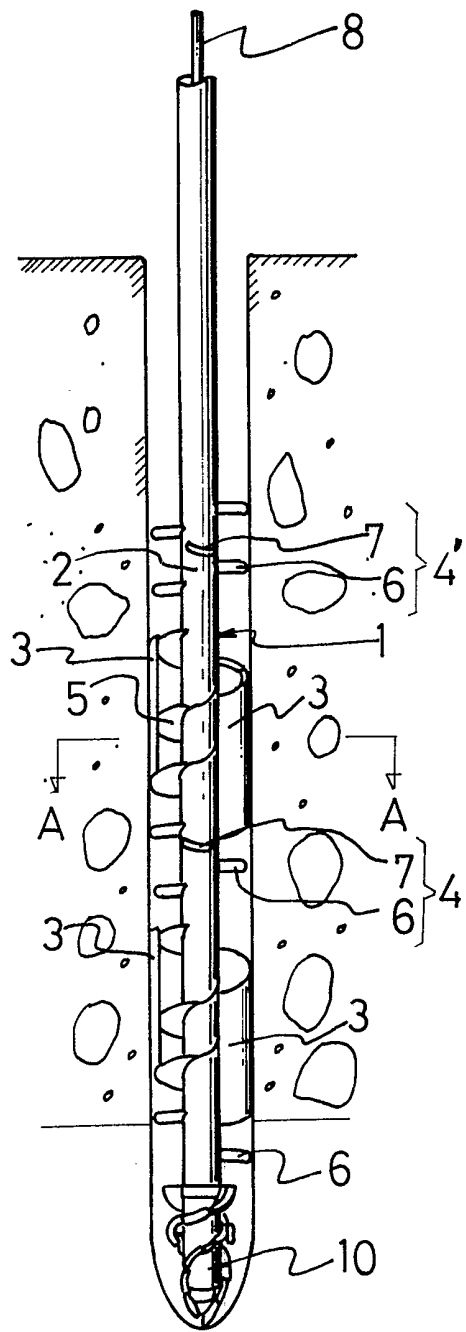


Fig.1(B)

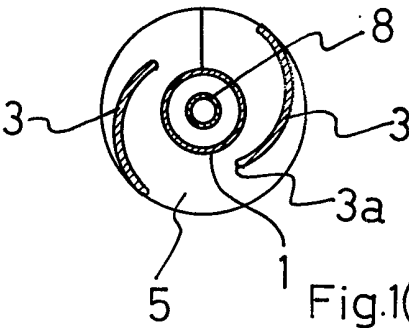


Fig.1(C)

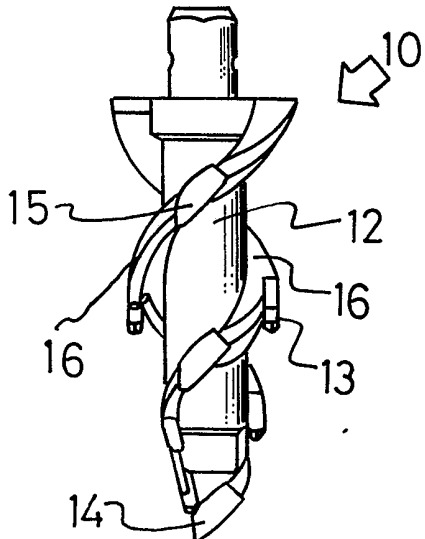


Fig.1(D)

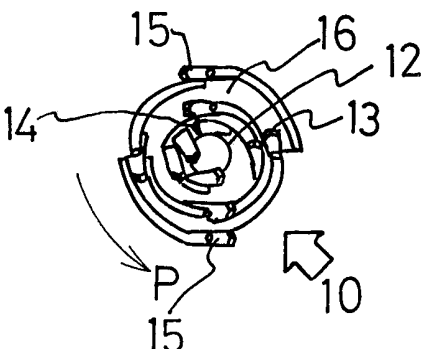


Fig.2(A)



Fig.2(B)

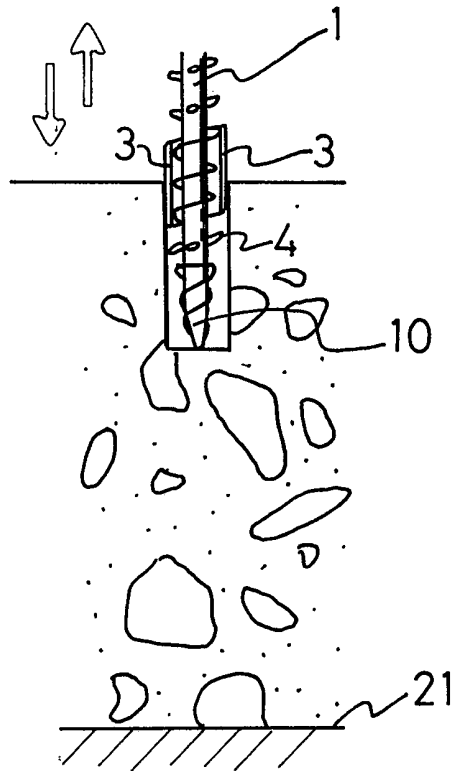


Fig. 2(C)

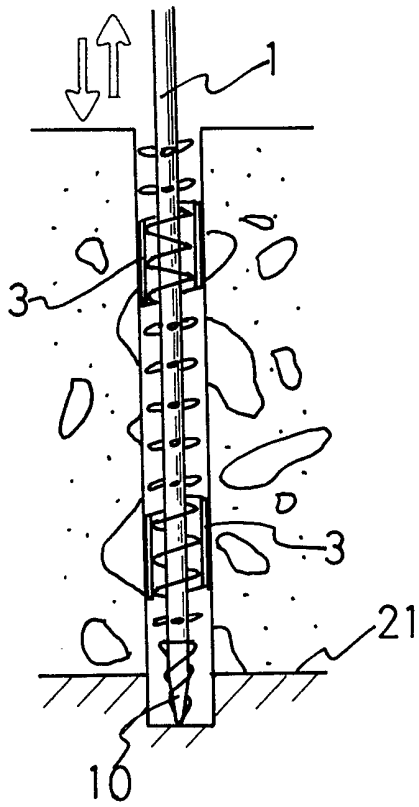


Fig. 2(D)

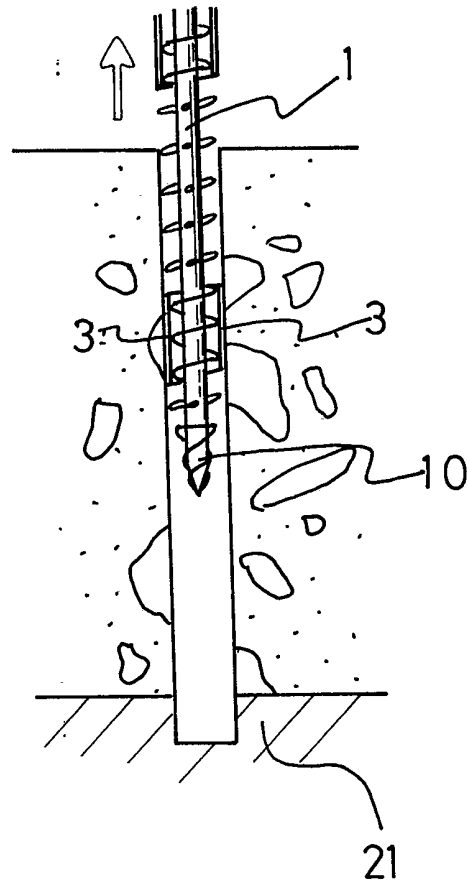


Fig. 2(E)

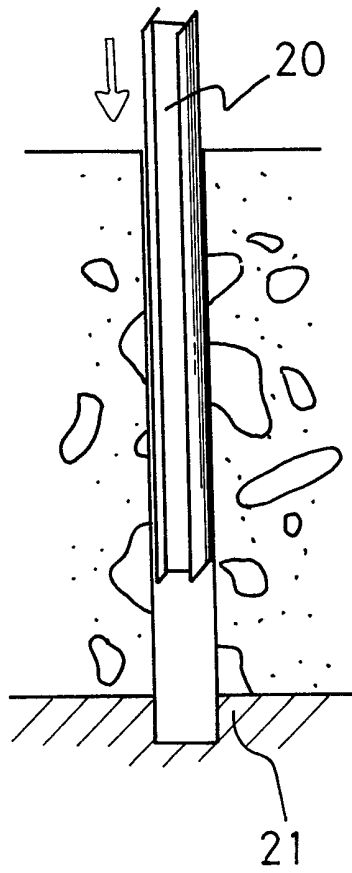


Fig. 2(F)

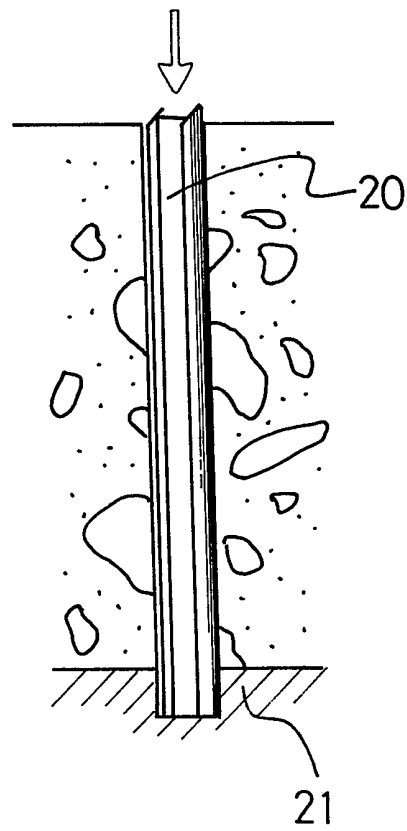


Fig. 3

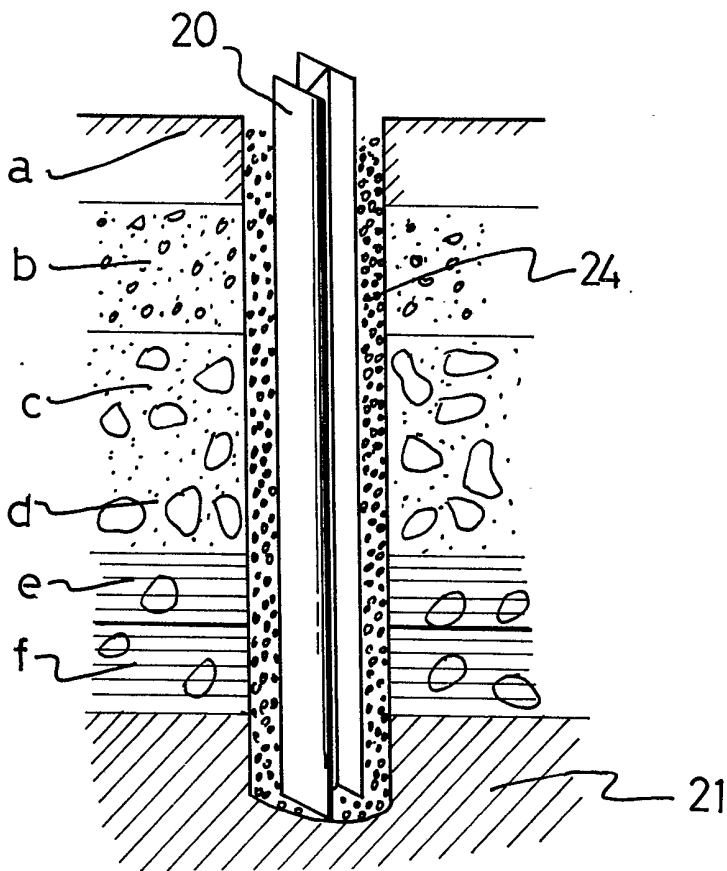


Fig. 4

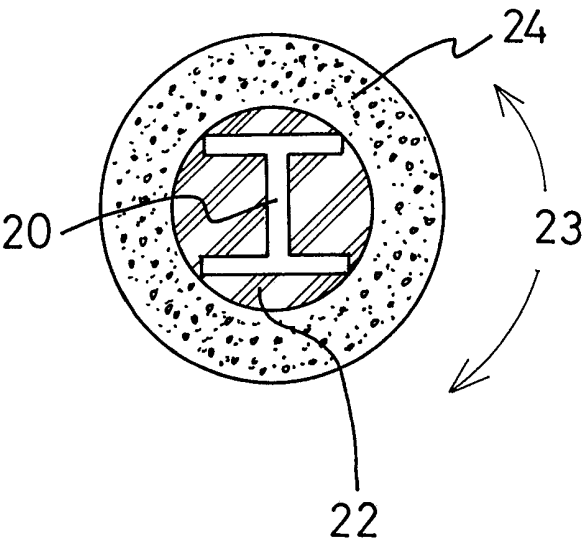


Fig. 5(A) 6/7

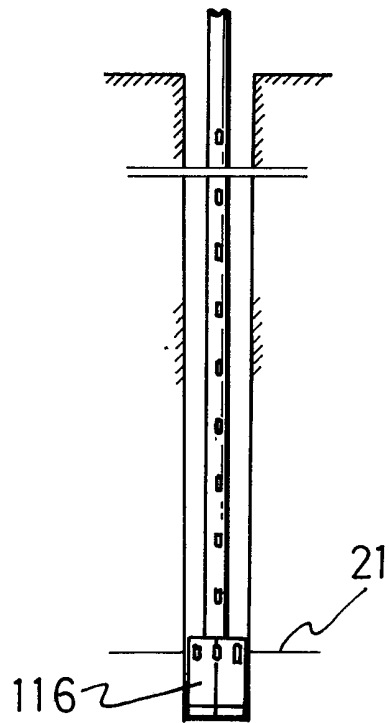


Fig. 5(B) 2137678

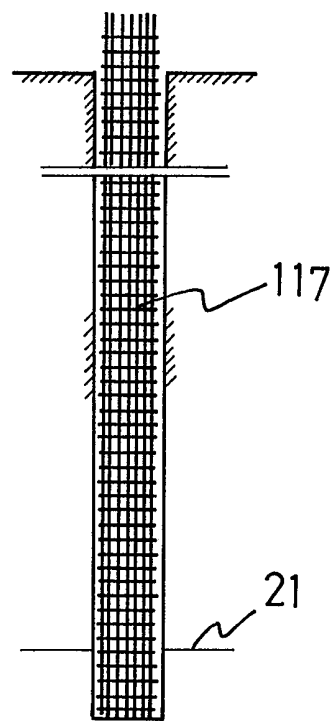


Fig. 5(C)

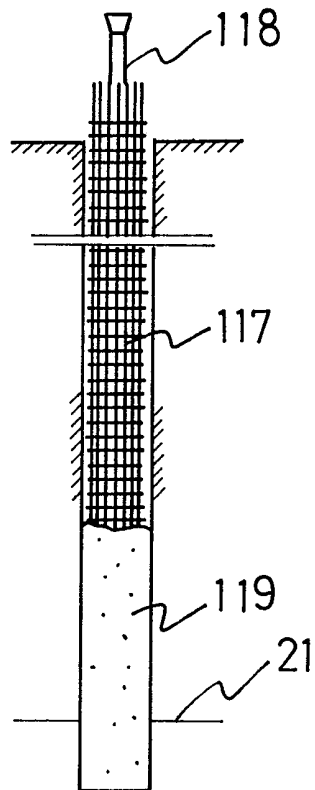


Fig. 5(D)

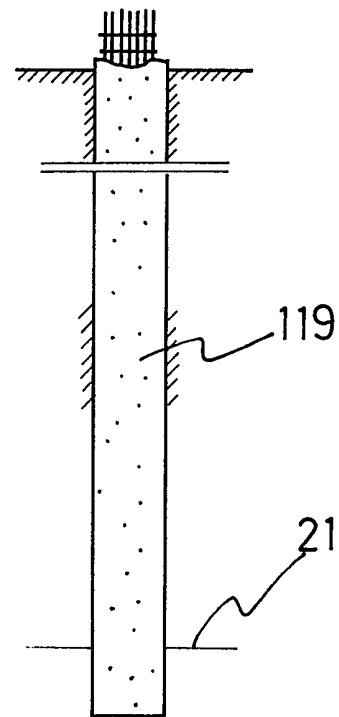
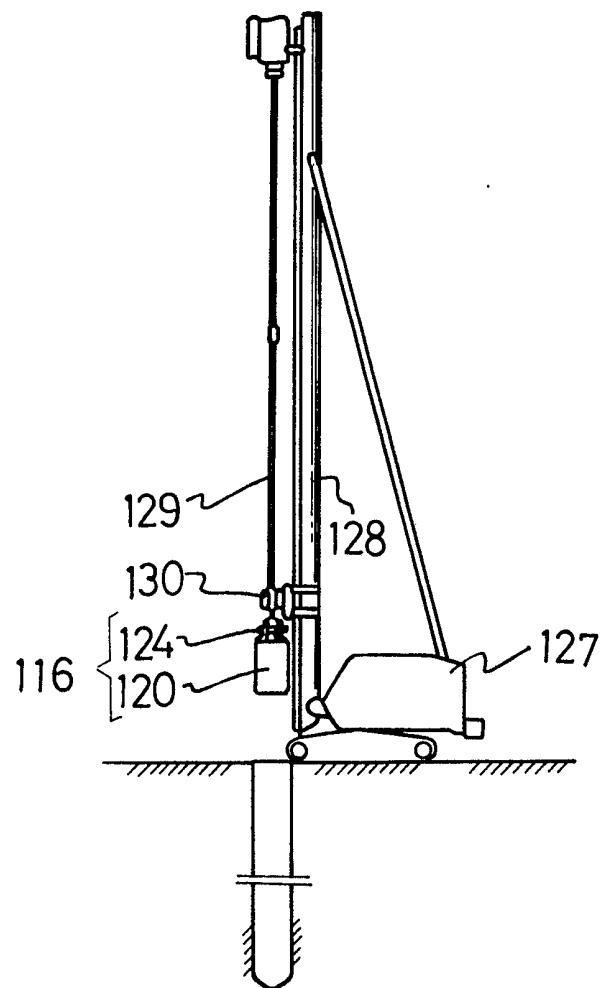


Fig. 6



SPECIFICATION

Method and apparatus for pile construction

5 This invention relates to a method for formation of a pile hole extending to a depth of 5
supporting stratum, and excavating apparatus for use in the execution of the method.

For pile construction without vibration and noise a method is well known in which, after
excavation by an auger, the pile is erected or constructed in the hole thus formed. With the
known method using the earth boring auger of the prior art, however, it has been impossible to
10 cope with various strata since the excavating operation has had to be interrupted when the 10
ground being excavated is hard or contains cobble stones or boulders and, particularly in silt
and pebble strata, even use of a stabilizer has usually been unable to prevent the pile hole wall
from collapsing. Furthermore, after excavation earth has been left clogging the spiral vane of the
auger and, in consequence the excavating operation has necessarily been carried out in an
15 intermittent manner, i.e. the earth left clogging the spiral vane has had to be removed before 15
the auger is reintroduced into the ground for completion of the desired pile hole. This has
inevitably imposed restrictions on working efficiency. Additionally, it has been necessary to
discharge the excavated earth out from the pile hole, resulting in making the working site dirty,
and earth disposal has also been required.

20 A principal object of the invention is to provide a method and an apparatus enabling pile 20
construction to be reliably and rapidly achieved, with almost no discharge from the excavated
hole being required and with continuous penetration of the auger into the ground being
possible. This object is achieved, according to the invention, by utilizing an improved auger
having a drilling ability and also adapted to utilize the excavated earth to seal the wall of the
25 excavated hole. 25

The invention will now be further described with reference to the accompanying drawings
which illustrate, by way of example, an apparatus and method embodiments in accordance with
the invention. In the drawings:

Figure 1 illustrates an auger embodiment, being the apparatus as used in accordance with the
30 invention for piling, in which *Fig. 1(A)* is a front view of the apparatus, *Fig. 1(B)* is a sectional 30
view on the line A-A in *Fig. 1(A)*, *Fig. 1(C)* is a front view of a cutter head thereof, and *Fig.*
1(D) is a bottom end view of said cutter head;

Figure 2 illustrates an embodiment of the method according to the invention, in which *Figs.*
2(A) to *2(F)* are sectional views respectively illustrating successive steps of this method;

35 *Figure 3* is a vertical sectional view of a pile prepared in accordance with the invention; 35

Figure 4 is a cross-sectional view of the pile and the construction around this pile;

Figure 5 illustrates another embodiment of the method according to the invention, in which
Figs 5(A) to *5(D)* are respectively sectional views illustrating successive steps of the method; and
Figure 6 is a side view illustrating the manner in which an excavating bucket is used.

40 First of all, the apparatus for piling according to the present invention will be described. 40
Referring to *Fig. 1(A)*, an excavating rod 1 of the auger has, around its lower portion 2, sealing
vanes 3 circumferentially curved and spaced from the peripheral surface of the rod 1 and
agitating vanes 4,4' radially projecting from the peripheral surface of the rod 1 above and below
each of said sealing vanes 3.

45 The sealing vanes 3 may be continuous circumferentially of the rod 1 or separated from one 45
another in that direction as illustrated (see *Fig. 1(B)* in particular). These sealing vanes 3 are
mounted on the periphery of a spiral vane 5 provided around the rod 1 and one lateral end 3a
of each sealing vane 3 is turned towards the peripheral surface of the rod 1.

The agitating vanes 4,4' are, for example, separated from one another not only longitudinally
50 but also circumferentially of the rod 1. They are in no case aligned circumferentially of the rod 1 50
and are alternately oriented. Here again, said spiral vane 5 is utilized for mounting these
agitating vanes 4,4'. Namely, the spiral vane 5 is cut off on diametrically opposite sides of the
rod 1 to form there sections of vane 6 and there are provided sections of vane 7 of opposite
orientation with respect to said section of vane 6 between respective pairs of adjacent spiral
55 vane portions on said diametrically opposite sides of the rod 1. These sections of vane 6, 7 55
together constitute said agitating vanes 4, 4'.

At its lower end the rod 1 is fixed to an aligned cutter head 10 having a cutting ability.

The cutter head 10 comprises a rod 12 adapted to be fitted and connected at the upper end
to the lower end of said rod 1, a plurality of intermediate cutter bits 13 arranged around the rod
60 12 at angular intervals of 90°, a lowermost cutter bit 14 projecting from the bottom end of the 60
rod 12, and a pair of uppermost cutter bits 15 arranged around the rod 12 symmetrically with
respect to the first pair of diametrically opposite bits 13 in the direction of rotation during use
(as indicated by an arrow P in *Fig. 1(D)*) and the axis of the rod 12. The respective tips of the
intermediate bits 13 are progressively situated at increasing distances from the longitudinal axis
65 of the rod, from the lowest one of these bits 13 to the highest one thereof, as can be seen from 65

Fig. 1(C) and 1(D). Reference numeral 16 designates mounting vanes for the cutter bits.

Said intermediate bits 13 not only have their tips at distances from the axis of the rod 12 which increase as the tips of the respective intermediate bits 13 are nearer to the uppermost end of the rod 12, but also the respective intermediate bits themselves are progressively
5 disposed further away from the axis of the rod 12 in said direction of rotation as indicated by the arrow P. The lowermost bit 14 has its tip eccentric to the axis of the rod 12. All the bits 13, 14 and 15 are directed in coincidence with said direction of the arrow P.

Said rods 1 and 12 contain an injection pipe 8 for bentonite liquid, cement milk or the like extending therethrough. They are connected at the upper end of the rod 1 to a rotary driving
10 device suspended for vertical movement from a derricking leader mast of a construction vehicle provided with a travelling mechanism comprising wheels, caterpillar tracks or the like (not shown).

The injection pipe 8 is connected at the upper end by a swivel mechanism mounted on said driving device to an injection hose coming from a separately installed batcher plant.

15 An embodiment of the method for pilling according to the present invention will now be described with reference to Fig. 2.

The rod 1 is rotated to urge the auger into the ground with vertical movement of the rod 1, if necessary, and thereby to form a posthole having a depth of approximately 10m and a diameter of 650mm, for example, (Fig. 2(A)). A stratum mixed with cobble stones and/or boulders
20 and/or bedrock encountered by the auger in the course of this operation will be effectively cut by the cutter head 10 at the rod end and, therefore, the operation is not interrupted.

The respective bits 13, 14 and 15 together constitute the cutter head 10 in the form of a drill preferable for linear penetration into the ground. As previously mentioned, the tips of the
25 respective intermediate bits 13 are more remote from the axis of the rod 12 as the tips of the intermediate bits are nearer to the uppermost end of the rod 12 and the respective intermediate bits 13 themselves are progressively spaced away from said axis of the rod 12 in the direction of rotation indicated by the arrow P. Thus, the cutting load is successively undertaken by these bits 13, permitting the cutting operation to be smooth and effective while the eccentric tip of the lowermost bit 14 also has a high cutting efficiency to facilitate penetration of the auger into
30 the ground. In this manner, the cutter head 10 cuts said cobble stones and/or boulders in the strata mixed with them and also cuts said bedrock to the supporting bed so that a rapid, reliable and linear drilling is achieved.

As this drilling operation with the cutter head 10 progresses, a quantity of bentonite liquid is injected through the injection pipe 8 and the tip of the cutter head 10 into the ground. First, the
35 agitating vanes 4 thoroughly mix the bentonite liquid with the excavated earth with agitation and then the sealing vanes 3 forcibly apply this mixture on the posthole wall. Residue of the mixture, if any, agitated and mixed by the agitating vanes 4' and gravels or the like produced by drilling are also forcibly embedded into the already sealed posthole wall further to assure the sealing effect. Thus, various strata can be reliably excavated and the posthole wall can be
40 effectively sealed to prevent the wall from collapsing. Furthermore, said posthole wall cooperates with the sealing vanes 3 to guide the auger so that the operation of drilling or excavation may be achieved linearly and continuously. The excavated earth is utilized to seal the posthole wall without discharge out of the hole or, if it is necessary to discharge any of it, the quantity to be discharged will be extremely small. Moreover, the desired sealing effect is
45 achieved with a relatively small quantity of bentonite liquid and it is sometimes even possible to utilize spring water instead of bentonite liquid.

After the auger has reached the supporting stratum 12, the rod 1 is positively rotated to withdraw the latter and thereby form the posthole (Fig. 1(D)).

During this withdrawal operation, agitation and mixing by the agitating vanes 4, 4' as well as
50 forcible application of the mixture on to the posthole wall by the sealing vanes 3 are repeated again just as during said excavation.

A prefabricated pile such as an H-section steel pile 20 or a concrete pile is now erected in the hole thus formed (Fig. 2(E) and 2(F)). In the erection of said H-section steel pile 20, a quantity of cement milk 22 is injected into a space around the pile root and the gap between the hole
55 wall and the pile. Such injection of cement milk is never disturbed by interference of ground water, since a high sealing effect in respect of the hole wall is obtained by means of the present invention.

With the auger excavation of the prior art, the excavated earth has usually to be discharged out of the pile hole and, in consequence, the ground around this hole is apt to be loosened.
60 With the method according to the invention, however, the excavated earth is forcibly applied on to the hole wall and this sealed layer 24 functions to reduce the void ratio (gaps) in the ground around the hole.

Particle sizes and void ratios in various strata when the method according to the present invention is not adapted are as follows:

	Stratum	Particle Size	Void Ratio	
	Loam	less than 0.0047mm	60 to 70%	
5	Sand	0.0048 to 19mm	35 to 45%	5
	Pebble	2.0mm or larger	25 to 35%	

When the method according to the invention is executed by using the apparatus according to the invention said void ratio is improved to 15 to 18% in loam, 9 to 13% in sand and 6 to 10% in pebble, respectively.

In view of the fact that sandstone and conglomerate generally have a void ratio of 0.4 to 6% while granite and slate generally have a void ratio of 0.04 to 0.06%, the method of the present invention has an effect by which sandy stratum and pebble stratum are brought into a condition similar to the condition of said sandstone or conglomerate.

Thus the hole wall is changed to a rocky condition so that it is effectively prevented from collapsing and, as a result, a self-supporting hole is formed.

When the prefabricated pile such as the H-section steel pile 20 is erected in the hole thus formed (Fig. 3), ground water acts to restore the hole wall progressively to the initial stratum or strata and thereby a compound stratum is formed, which functions to hold the H-section steel pile 20 or the like firmly (Fig. 4).

As will be obvious from the foregoing description, the hole thus formed by the method according to the invention using the apparatus according to the invention is optimal for erection of said prefabricated pile therein.

Referring to Fig. 3, *a* designates surface soil, *b* designates sand-and-pebble stratum, *c* designates intermediate stratum, *d* designates large pebble stratum, *e* designates loam stratum and *Df* designates poor subsoil.

In the pile hole formed by using the apparatus according to the invention, it is also possible to erect a cast-in-situ pile instead of the prefabricated pile described. A method to be adopted in this case will now be described.

After the step corresponding to Fig. 2(D) has been completed, a discharging bucket 116 is introduced into the pile hole and the excavated earth is discharged from the hole (Fig. 5(A)). At the same time slime discharging may also be carried out. A steel cage 117 is erected in the pile hole (Fig. 5(B)). Then, the interior of the pile hole is filled with concrete 119 through a tremie 118 (Fig. 5(C) and 5(D)).

As said discharging bucket 116, various types may be used, such as a bucket adapted to be symmetrically divided or a bucket of auger drilling type. In any case, the bucket proper 120 is mounted by a connector 124 on an end of a supporting shaft 129 which is, in turn, suspended from a leader 128 of a pile driver 127 and supported at the lower end by a steady rest 130.

In accordance with the invention, as will be understood from the foregoing description, a pile construction free from vibration and noise can be continuously, linearly and precisely carried out. This can be achieved substantially without discharging excavated earth from the hole, no matter when pebble stones or the like are present in the strata, and thereby said stated object of the invention can be adequately achieved.

The cutter head used for the apparatus of the invention adopts, in addition to the well-known bit arrangement which is able to hold the cutter head in the form of a key suitable for linear penetration of the cutter head into the ground, a novel arrangement such that the tips of the respective intermediate bits are more remote from the axis of the rod as the tips of the respective bits are nearer to the uppermost end of the rod, the respective intermediate bits themselves being progressively spaced away from said rod axis in the direction of rotation indicated by the arrow P. Thus a cutting load is successively undertaken by these bits, permitting the cutting operation to be smoothly and effectively accomplished and the eccentric tip of the lowermost bit also has a high cutting efficiency to facilitate penetration of the auger into the ground, so that the cutter head cuts said cobble stones and/or boulders in the strata mixed with them and also cuts said bedrock to the depth of the supporting bed so as to achieve a rapid, reliable and linear drilling. In particular, the present invention can realize an excavation speed about five time faster than the excavation speed which has usually been achieved by the corresponding cutter head of the prior art.

60 CLAIMS

1. A method for pile construction using a pile hole formed to a depth of supporting stratum utilizing an auger: said method comprising the steps of excavating to the depth of supporting stratum by using said auger which has a rod supporting sealing vanes spaced from the peripheral surface of the rod and circumferentially curved, agitating vanes projecting radially from said peripheral surface, and a cutter head mounted on the lower end of the rod;

withdrawing the auger by positively rotating the rod; and then erecting a prefabricated pile such as an H-section steel pile or a concrete pile in said hole.

2. A method for pile construction using a pile hole formed to a depth of supporting stratum utilizing an auger: said method comprising the steps of excavating to the depth of supporting
5 stratum by using said auger which has a rod supporting sealing vanes spaced from the 5 peripheral surface of the rod and circumferentially curved, agitating vanes projecting radially from said peripheral surface, and a cutter head mounted on the lower end of the rod; withdrawing the auger by positively rotating the rod; erecting a steel cage in the hole; and filling the interior of the hole with concrete.
- 10 3. An apparatus for pile construction comprising a rod; sealing vanes which are spaced from 10 the peripheral surface of the rod and circumferentially curved; agitating vanes projecting radially from said peripheral surface; and a cutter head mounted on the lower end of the rod.
4. Apparatus according to claim 3, wherein said cutter head comprises its own rod pairs of
15 of these intermediate bits symmetrically arranged with respect to the axis of the rod with respective tips 15 of these intermediate bits being more remote from the axis of the rod as the tips are progressively nearer to the upper end of the rod with the intermediate bits themselves being progressively further away from the axis of the rod in the direction of rotation when in use, and a lowermost bit having its tip eccentric to the axis of the rod.
5. A method for pile construction employing an auger adapted to utilize the excavated earth
20 to seal the hole wall, substantially as herein described. 20
6. A method for pile construction, substantially as herein particularly described with reference to Figs. 2 to 4, or Fig. 5, of the accompanying drawings.
7. Apparatus for pile construction, substantially as herein particularly described with reference to Fig. 1 of the accompanying drawings.