

Sept. 21, 1965

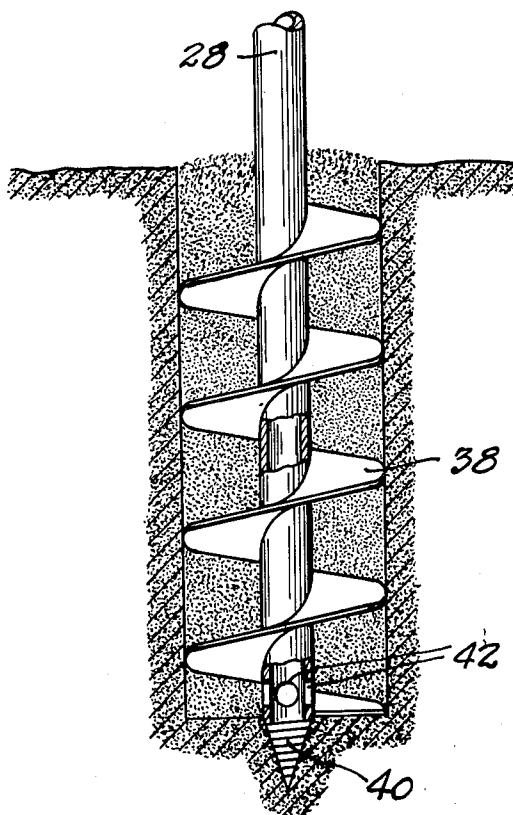
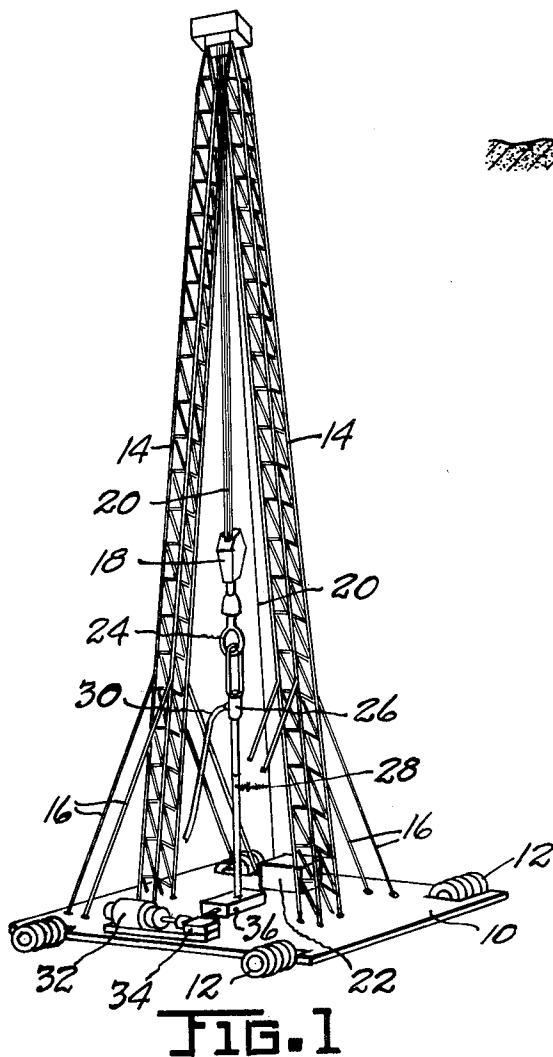
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3,206,936

METHOD AND MEANS FOR MAKING CONCRETE FILES

Filed Dec. 15, 1960

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

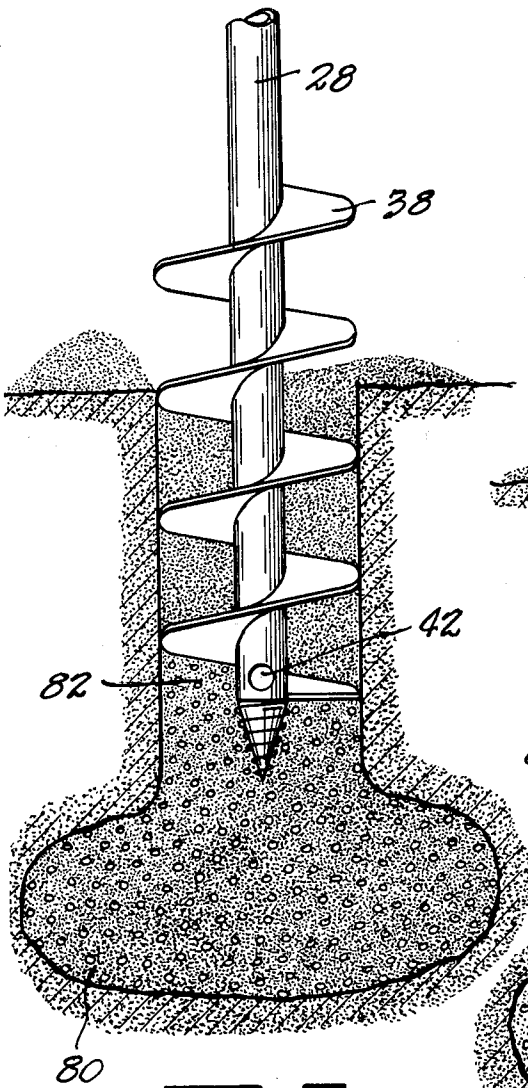


FIG. 3

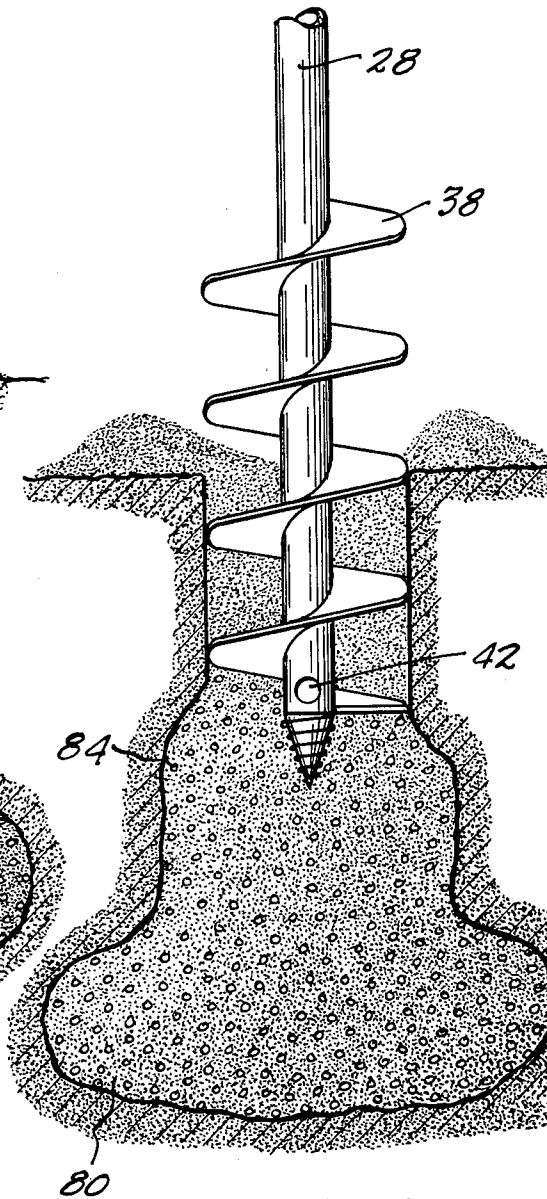


FIG. 4

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4 Sheets-Sheet 3

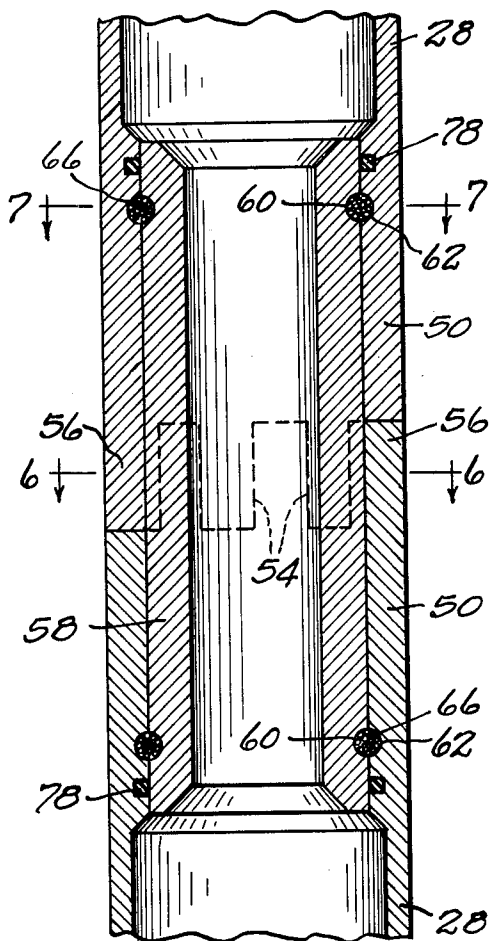


FIG. 5

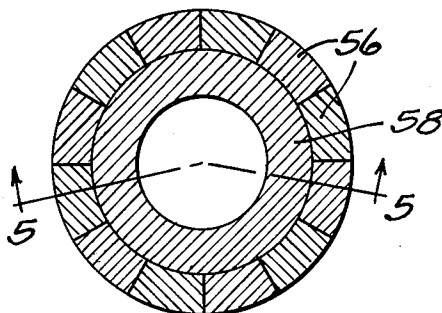


FIG. 6

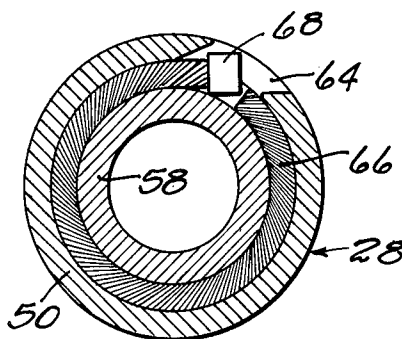


FIG. 7

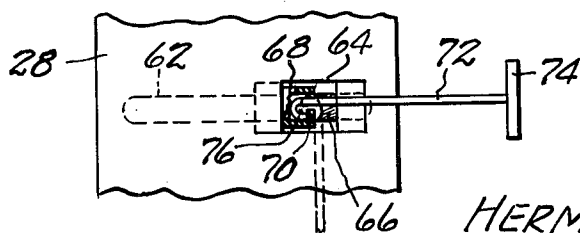


FIG. 8

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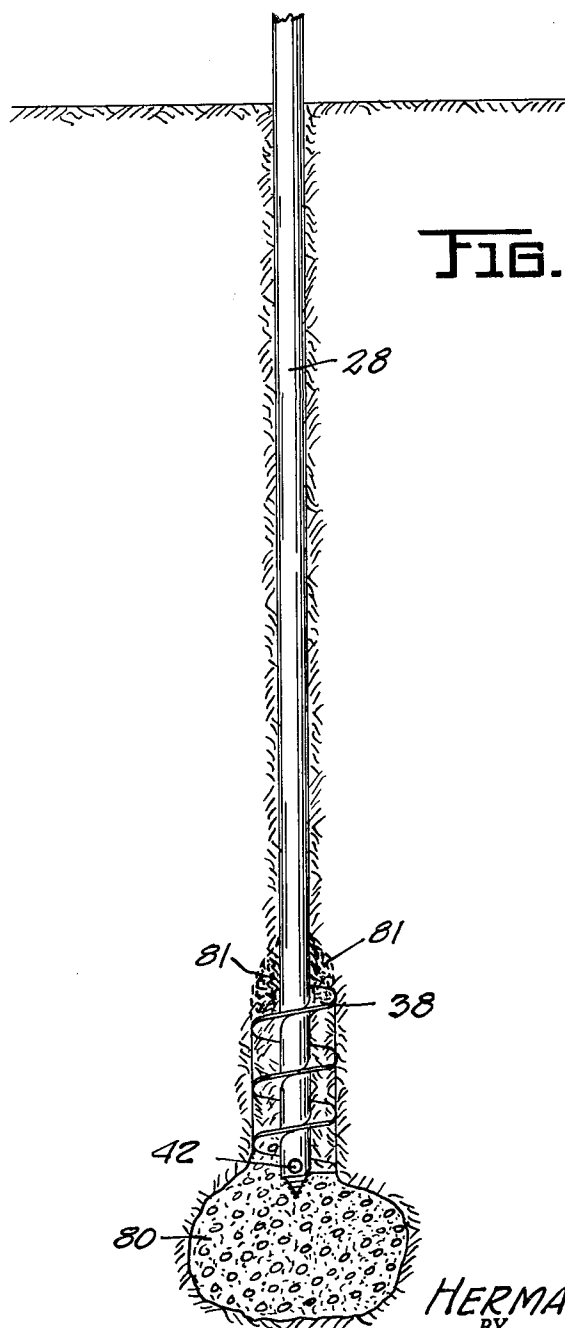


FIG. 9

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3,206,936

METHOD AND MEANS FOR MAKING CONCRETE PILES

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7 Claims. (Cl. 61—53.64)

This invention relates to a method and means for making concrete piles, and more particularly to a method for making or casting concrete piles in situ.

The primary object of this invention is to provide a rapid, economical and reliable method for making concrete piles in situ without the necessity of using forms therefor separate from the earth itself.

A further object is to provide a method of making concrete piles in situ in a soft soil which normally tends to collapse into a hole formed therein as said hole is opened.

A further object is to provide a method for producing concrete piles in situ which are characterized by an enlarged lower subsurface portion which provides good support in soft ground and which displaces and radially compresses soil therearound whereby said pile has maximum strength and maximum supporting properties.

A further object is to provide a method of forming a concrete pile wherein a drilling member having a hollow stem is forced into the earth to a predetermined depth and then is partially raised to provide a clearance space sealed by said member and by the soil around the flights of said member into which clearance space concrete is discharged under pressure to enlarge and fill said space while said member is held substantially stationary, and thereafter said member is withdrawn and concrete is fed through said stem and discharged below said member simultaneously.

A further object is to provide a method of forming concrete piles which includes the step of feeding concrete through the hollow stem of a member driven into the ground for discharge into a hole in the soil below said member while that hole is sealed above the point of discharge by the stem and by soil encircling said stem, said discharge occurring while said member is substantially stationary and under a pressure sufficient to radially enlarge the hole in the soil adjacent to the point of discharge and to densify the soil around the enlarged part of the hole.

A further object is to provide means for producing a concrete pile including an auger having a hollow stem and formed in a plurality of sections detachably connected by a novel joint accommodating all stresses applied in rotation while drilling and in the withdrawal of the drill from the soil by pulling thereof.

A further object is to provide a soil-drilling auger having a hollow stem and formed of multiple parts wherein means are provided to interconnect the stem parts in a manner to provide an effective fluid seal at the interconnection, to prevent relative rotation of the parts of the stem and to releasably lock the stem parts against separation thereof lengthwise.

A further object is to provide a method of forming concrete piles wherein an auger with multiple flights and a hollow stem open near its tip is advanced into the ground to form a hole with minimum removal of soil and in a manner to fill the space between the auger flights thereof with soil and thereby seal the hole by means of the auger and whereby the auger and the retained earth are lifted to a position clear of the bottom of the hole while concrete is fed through the bore under pressure to radially enlarge the lower part of the hole.

A further object is to provide a method of forming concrete piles wherein a minimum of soil is removed

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in producing the pile, wherein an enlarged bulbous bottom portion is formed on the pile to produce a maximum bearing capacity of the pile, and wherein soil is radially compressed around the pile throughout its length.

Other objects will be apparent from the following specification.

In the drawings:

FIG. 1 is a perspective view of an apparatus employed for practicing the method, with parts thereof broken away;

FIG. 2 is a view of a part of the apparatus employed in the performance of the method, illustrating the same at a location for the performance of one step of the method, and with parts thereof shown in section;

FIG. 3 is a view illustrating an intermediate step in the performance of the method;

FIG. 4 is a view illustrating an intermediate step in the performance of the method under slightly different conditions than those illustrated in FIG. 3;

FIG. 5 is an enlarged longitudinal detail sectional view of a part of the apparatus, taken on line 5—5 of FIG. 6;

FIG. 6 is a transverse sectional view taken on line 6—6 of FIG. 5;

FIG. 7 is a transverse sectional view taken on line 7—7 of FIG. 5;

FIG. 8 is a fragmentary side elevational detail view of the portion of the device illustrated in FIG. 7; and

FIG. 9 is a view illustrating an intermediate step in the performance of the method.

My new method entails the following procedure. An earth-penetrating member having a hollow stem and open near its tip and which may constitute an auger having any selected number of flights is forced into the ground in any suitable manner and by any means as well understood in the art. Earth penetration will preferably entail rotating the auger until it reaches the desired depth, as illustrated in FIG. 2. In very soft ground it may be possible to force the penetrating member into the ground to the full depth desired without rotation thereof. In slightly firmer soil it may be possible to obtain rapid penetration of an auger by pressing downwardly thereon while rotating the auger backwardly. In still firmer ground the auger may be screwed into the ground. In most instances, the auger, when used, will be rotated while vertical action is controlled so as to permit increase or decrease of the rate of descent, stopping of the auger, or reverse of the rotation thereof. Such controlled action may be altered intermittently or continuously as may be required by conditions encountered in the operation. Where rotation is involved, it continues only until such time as the desired depth is reached, whereupon it is stopped to insure that soil is left in the hole formed by the auger or other penetrating member substantially full depth so as to seal around the stem and at the flighted portion of the auger. If necessary, soil may be purposely compacted around the auger flights by reversely rotating the auger after it reaches desired depth.

The penetrating tool is then lifted, preferably without rotation thereof, for a small part of the depth of the hole to provide a clearance space at the bottom of the hole adjacent the discharge opening of the hollow stem of the tool. The penetrating tool is then held in this position and concrete or grout is then forced through the hollow stem of the tool under selected pressure which may extend to 1000 p.s.i., or more. The supply of grout under pressure through the hollow stem of the tool continues as required to produce enlargement of the clearance space or cavity around the lower end of the tool and as long as the cavity continues to accept the grout, while the penetrating

tool and the earth therearound seals off the opening in the earth. When the cavity will no longer accept more grout at the selected pressure while sealed by the penetrating tool, the tool is raised at a rate that preferably is substantially in proportion to the rate at which grout is supplied. However, the rate of withdrawal of the tool may be correlated to the rate of grout supply and/or to the pressure of grout supply to maintain pressure underneath the tool as the tool is elevated so as to continue to expand the hole radially intermediate its depth. Preferably, grout pressure is reduced to substantially zero as the grout level in the hole nears the surface of the ground. The rate of pressure reduction and the point at which pressure is reduced are preferably controlled according to soil conditions at the site and other considerations. The purpose of this pressure reduction as the grout level nears ground level is to prevent heaving of the soil around the hole and to prevent the grout from breaking through the seal between the tool and the earth carried thereby, on the one hand, and the walls of the hole.

In extremely weak soils where the specific gravity of the grout is higher than that of the soil, careful control of grout pressure must be exercised to limit the flow of grout into the soil around the hole. This necessitates control of grout supply responsive to comparatively slight changes in pressure, rate of flow, volume, time or other factors. One condition which may occur if excessive grout pressure is applied is that the displaced soil may be forced to flow such a distance and in such a manner as to grip the penetrating tool or auger so tightly that withdrawal of the auger is prevented despite the fact that the auger is designed to provide great strength and to sustain great lifting forces applied thereto.

One form of apparatus by means of which this method may be practiced is illustrated in FIG. 1. This apparatus may be wheeled for mobility and dirigibility and may constitute a support or platform 10 suitably mounted upon wheels 12 to render it mobile. A tower may be formed of one or more elongated structural members 14 carried by the base 10 and suitably guyed or supported, as at 16. The tower may carry an upper sheave (not shown) around which and a lower sheave 18 is trained a cable 20. One end of the cable may be connected to a powered winch 22 or other suitable means for elevating and lowering the lower sheave 18. The lower sheave 18 may carry means 24 for suspending a conventional "mud swivel" 26 of the type used in oil-drilling rigs, to which is connected the upper end of a tubular member or hollow stem 28 of a soil-penetrating member, such as an auger. Stem 28 may be of one or more sections. A conduit 30 may extend from the mud swivel 26 to a pressurized source of supply of concrete or grout (not shown), such as a variable pressure pump or impeller. The swivel 26 will preferably be sealed to discharge concrete or grout only to the stem 28.

Any suitable means may be provided for rotating the tubular member 28, such as an engine or motor 32 having a speed reducer 34 associated therewith and serving to drive tube-rotating and advancing means 36 of any character well understood in the art.

The tube 28 forms a part of a soil-penetrating member, here shown as an auger having a plurality of flights 38 whose diameter determines the diameter of the hole formed in the soil to receive the piling. The ratio of the stem diameter to the outside flight diameter may vary and, in some cases, stem diameter may be as much as 75% of outside flight diameter. The number of flights utilized may be determined in part by the character of the soil being encountered. Thus in places where soft soil is encountered, only a few flights may be required. Where the soil is firmer, more flights may be required. In hard soil it may be necessary to provide a sufficient number of flights to insure that the entire portion of the penetrating tool which penetrates the hard soil will be flighted. A tip member 40, preferably of solid character, tapered and which may be spirally ribbed, is mounted upon the tube

28 at its end in concentric relation thereto to project beyond the leading or lowermost end or flight 38. The leading end of the flight may be sharpened by beveling thereof and may carry a wear plate (not shown), if desired. One or more apertures 42 are formed in the lower end of the tube 28 adjacent to the leading end of the auger flight 38 and to the tip 40.

In instances where the depth to which the pile is to extend is such as to require formation of the stem or tube 28 from a plurality of sections, a construction as illustrated in FIGS. 5 to 8, inclusive, may be utilized to join the tube sections. The tube sections to be joined are preferably provided with end portions 50 of thickened wall section with the exterior diameter thereof preferably substantially constant and the interior diameter at the thickened portion less than the interior diameter of the major portion of the tube. The tube ends are notched at 54 to define teeth 56. The teeth 56 of the adjacent tube sections are adapted to interfit or mate when the tube sections are aligned and brought into end abutment, as illustrated in FIGS. 5 and 6. An elongated tube section 58 has an outer diameter fitting snugly within the enlarged portions 50 of the tube sections and adapted to span the joint between said tube sections, as seen in FIG. 6.

Adjacent each end thereof the tube 58 has an external circumferential groove 60. Each of the thickened wall portions of the tube sections has an inner circumferential groove 62. The grooves are spaced similarly to the spacing of the grooves 62 when the teeth 56 of the tube sections mesh, as seen in FIG. 5. Each of the tube sections 50 has an opening 64 therein so located as to interrupt the inner circumferential groove 62 and preferably extending substantially tangentially, as distinguished from radially, as best seen in FIG. 7.

An elongated flexible key member 66, such as a flexible wire cable of a diameter to have a snug sliding fit within the registering grooves 60, 62 and insertable into place and withdrawable through the opening 64, serves as means to anchor the inner tube 58 in fixed relation in the end sections 50 of the tube sections 28. A socket member 68 is fixedly mounted upon the end of the flexible member 66 and is preferably of the character having a transverse flange 70 extending partially across the mouth thereof, as seen in FIG. 8. The length of the member 66 will preferably be such that it will extend substantially completely around the inner tube 50 while permitting reception of the socket 68 within the opening 64 to be confined within the outline of the opening 64. A hook member having an elongated shank 72, a handle 74 and a hook-shaped end portion 76 provides means for withdrawing the flexible key 66 when the tube sections 28 are to be disconnected. The hook end is readily engaged with the socket 68 by inserting the hook end 76 in the opening of the socket 68 while the shank 72 is held in the dotted line position shown in FIG. 8, whereupon the tool can be swung to the full line position shown in FIG. 8 for interengagement of the parts 70 and 76. A reverse movement of the tool releases it from socket 68.

In some instances it may be desired to provide a fluid-tight seal at the joint, particularly in cases where high grout pressure is to be exerted. In such instances one of the telescoping parts 50 and 58 may be circumferentially grooved adjacent each end of the inner tube 58 to receive an annular resilient sealing member 78, such as an O-ring, in the manner well understood in the art.

In the practice of the method utilizing this apparatus, a penetrating tool having a desired number of flights as determined by the character of the soil to be penetrated, is mounted in the apparatus, as by connection with a tube section by means of the joint illustrated in FIG. 5. The penetrating tool is advanced, as by rotation thereof by the driving means 32, 34, 36, until it reaches the desired depth, and usually until the flights are spaced below ground level. The tool is stopped while soil is retained around the stem

28 and between the flights 38, as illustrated in FIG. 2, and in the event soil is not retained around the flights, the penetrating tool may be reversely rotated while feeding soil between the flights thereof or into the upper end of the hole. Thereupon the winch mechanism is operated to lift the tube 28 to a slight extent and preferably to a position just slightly above the position illustrated in FIG. 2 with respect to the bottom of the drilled hole and spaced below the position illustrated in FIG. 3. Thereupon, grout is fed under selected pressure through the conduit 30 into the tube 28 and thence through the same to the discharge openings 42.

It will be observed that the initial slight elevation of the penetrating tool after the hole has been formed to full depth provides a clearance around or adjacent the openings 42 so that any soil which is located adjacent to outlet openings 40 and which tends to plug or span the same is readily displaced by the grout under pressure so that the grout is free to escape into the hole. Note that the withdrawal of the penetrating tool has been forcible so as to cause soil displacement on the auger upstroke insofar as the soil between the flights is concerned. This is of slight extent only and does not entail sufficient removal of soil from the hole to interfere with tightness of a seal at the upper portion of the hole required to confine the grout which is discharged into the clearance space at the bottom of the hole.

As the grout is released underground even in extremely soft soil, a considerable reaction is built up as the mass increases. The size and shape of the discharged grout will depend upon the conditions existing at the strata of discharge and will normally be characterized by a greater travel horizontally than vertically. Thus the average concrete mass as formed will usually have a diameter or transverse average dimension from two to three times its maximum vertical dimension, although in some cases it may assume a substantially spherical shape.

The body of grout discharged at the bottom of the hole in the practice of this method will expand until the immediately surrounding soil is compressed. This compression factor will vary with different soil and under different conditions of moisture, compaction, particle size, particle shape, grout fluidity, maximum grout particle size, and other features. As the compression commences, the grout under pressure first penetrates the soil particles surrounding it for varying distances. Then as soil openings are bridged by grout particles, the soil begins to yield or to compress. The compression of the soil reduces the escape paths for the grout still more, and escape will eventually cease entirely. As the grout body continues to enlarge and expand, compressive effort upon the soil is transmitted further from the point of release.

In one test made near Batesville, Mississippi, in a hole in saturated alluvial silt and sandy loam at a depth of less than fifteen feet and underneath about ten feet of ground water, after more than five cubic feet of fluid grout had been injected, the hole refused to accept more grout when a pressure of 400 p.s.i. was reached. The point of escape of grout can vary from time to time during a grout-filling operation as new paths of escape are forced open. This will result in the building up of pressure followed by rapid drop off of the pressure as a new path of escape is opened. Usually, however, new paths will seldom develop after an initial pressure of about 200 p.s.i. has been reached. It will be obvious that if adequate pressure capability in the grout plant or pumping unit is provided, a reaction of almost any desired value can be developed at the foot of the pile, particularly with conventional pumps now commercially available which are capable of pumping grout against a pressure of as much as 14,000 p.s.i.

After the formation of the initial subsurface bulb or enlargement of the concrete, as at 80 in FIG. 3, the penetrating tool is pulled by operating the winch 22 while continuing to feed grout at a lesser pressure. In this connection it is normally preferable that the bulb 80 should

produce the necessary reaction value and that the cross-section of the remainder of the pile should be less than that of the bulb. Thus, in FIG. 3, is illustrated an arrangement wherein a portion 82 of the pile is of a diameter substantially the same as the diameter of the fighting on the penetrating tool. In FIG. 4 is illustrated a condition in which the transverse dimension of the portion 84 of a pile above the bulb 80 is less than that of the bulb but slightly greater than the diameter of the hole formed by the fighting on the penetrating tool. The FIG. 4 condition exhibits soil compression which will produce support of the pile from said friction in addition to that provided at the bottom of the bulb 80.

FIG. 9 illustrates an intermediate step in the pile-forming method wherein the flighted portion 38 of an auger of short length, compared to the depth of pile desired, is run or screwed into the soil with minimum disturbance of the soil around the auger and between the flights thereof. The space occupied by the stem 28 and fighting 38 was produced by displacement of an equivalent volume of the original soil. Consequently, when the auger is elevated without rotation from its position of greatest depth to the FIG. 9 position, the earth between the flights is carried upward by the fighting and shear occurs at the outer edge of the fighting. Hence the fighting and the contained earth constitutes a volumetric and radial enlargement of the stem whose upward movement forcibly compacts and displaces the soil thereabove at 81. The compaction at 81 produces an effective packing and seal around the stem 28 to prevent escape of grout, as at the shear around the fighting 38, as the bulb 80 is formed. After bulb is formed, continued lifting of the auger without rotation maintains intimate contact between the upper part of fighting 38 and the overlying soil and maintains a positive continuing seal as the compacted soil portion 81 is elevated coincident to continued lifting of the auger and grout continues to be discharged under pressure.

One of the advantages of the pressurized uncased concrete pipe produced by this method is that the penetrating tool or auger itself serves as the instrument by which the ultimate capacity of the pile may be estimated. For example, using a six-inch stem with five feet of fighting on ten-inch pitch with 12-inch outside diameter produces a hole with 1.57 square feet of surface for each linear foot of the stem, 7.54 square feet of surface on the top and bottom of the fighting, and an external shear line of 19.5 feet in length measured helically along the outer edge of the fighting, and an external 14.14 square feet of surface of the fighting and entrained earth, after allowing for loss of earth in the end convolution. If an auger having these dimensions is screwed into the ground for five feet and then pulled out vertically, the effort required to start movement, and the maximum effort required to completely shear the entrained earth, will represent the friction capacity, and the failure point, respectively, of a five-foot pile cast in the hole under pressure slightly greater than the original soil pressure. By using the penetrating tool or auger to measure the initial and failure loads for each five-foot increment, and by adding these two values to obtain their respective sums for the entire embedded length, the friction capacity of the finished pile can be accurately determined, and the failure load also established. In cases where the auger can be screwed to full length without exceeding the lifting capacity of the hoisting apparatus, the final forward torque in foot pounds may be measured, multiplied by two, because the stem is only one-half the pile diameter, and multiplied by two again because the shearing effort was applied at one-half the radius of the completed pile. The result may be taken as the frictional value for the pile. It may be mentioned that in this rough formula the effect of the fighting is neglected because the dynamic shear value of the auger stem is far below the shear value of an equivalent area of the finished pile. Then, by adding the friction and the

point resistance, the total capacity of the pile will be calculated.

When the auger is run to full depth in a single pass, the withdrawal effort plus the pressure record during withdrawal, plus the volume record for concrete injected in bulb and stem increments, will provide the basis for computing the pile capacity through determination of the interface contact areas and pressures for the entire imbedded surfaces.

An example of computation of the point resistance of a completed pile from the volume and injection pressure of concrete forced into the pile bottom follows. Assuming that a 12-inch pile is to carry a design load of thirty tons and to support a test load of 60 tons without undue settlement, a computation of these assumed values will reveal that the pile must sustain a load of 1,060 pounds per square inch of stem section. Since concrete developing at least three times this compressive value is easily mixed and pumped, the stem has a design safety factor of at least six under all normal circumstances. Assuming further that the entire 60 ton test load is to be supported by point resistance and that stem friction is to be entirely disregarded, then if the volume of grout injected below the auger exactly equals the void created by the rising auger and a grout injection pressure of 1,060 pounds per square inch is being maintained below the auger, it is evident that the bottom of the hole is sustaining a load of 60 tons and that no further lateral displacement of the soil is occurring. If now the auger-lifting and grout-pumping actions be stopped and the pressure below the auger does not decrease, the desired requirement is met and the pile will support a load of 60 tons. Such a situation might occur in rock or in very strong soil, such as hardpan but in most instances the grout cavity below the auger will expand by reason of hydraulic action and the surrounding soil will be compressed and displaced to the same extent.

If grout-pumping is continued while total auger lift is maintained and is limited to a dimension equal to the diameter of a sphere whose volume equals that of the injected grout, a generally spherical mass of grout can be developed. Since the bottom of the grout mass is already defined to the bottom of the hole and the top is defined by the under side of the auger, lateral expansion can be expected to be fairly uniform and symmetrical except in unusual circumstances. The load-supporting capacity of such a concrete mass increases approximately in proportion to the square of the cube root of the volume. If the pile point is considered as being perfectly spherical, its supporting capacity is proportional to the square of the diameter. The volume will vary as the cube of the diameter, and the contact pressure, i.e., grout injection pressure, will vary in inverse proportion to the square of the diameter if uniform load-supporting capacity is to be maintained.

Assuming a sphere having a volume of one cubic foot the same will have a diameter of 1.2048 feet and a projected area of 1.2092 square feet. When such a sphere is confined by the soil at uniform contact pressure of 688 p.s.i., it starts a reaction of 60 tons in all directions and will support a vertical load of 60 tons.

It is thus apparent that a pile point of almost any reasonable load capacity can be constructed in most soils by observing and maintaining the necessary volume-pressure-lift ratio. It is also apparent that the minimum safe bearing capacity of the pile point can be determined from volume-pressure-lift measurements and that piles can thus be constructed to meet standards of performance with precision and certainty, provided only that the measurements be made with reasonable accuracy and sound construction techniques are followed.

I have found that a generally accepted rule that indicates that grout pressures must be limited to one pound per square inch per foot of cover is grossly erroneous in most instances. Thus, although it is true that heaving can occur with a cover-pressure ratio of one, it does not

ordinarily occur and experienced grouting operators will find little difficulty in retaining grout in soil at a cover-pressure ratio of one to ten, or even as high as one to one hundred, in most soils. All essential data on soil characteristics can be measured or determined in the field as a part of the normal pile operations and the engineer or other operator can readily choose a pile depth, dimension and injection pressure which will result in the most economical or most satisfactory foundation.

In the foregoing computations it is understood that all forces are the net effort after weight and non-functional friction are considered. It should also be understood that all computed pile capacities must be weight corrected by the differences between the concrete pile and the volume of the earth it has displaced.

I am aware that it has previously been proposed to form a hole to desired depth by the use of an auger and to fill that hole with concrete as the auger is withdrawn. However, the methods previously known do not provide positive means for confining the concrete underneath the stationary auger until the desired volume can be injected to expand the concrete bulk in soft ground and thereby develop a vertical reaction equal to the full capacity of the pile stem. In some instances in prior methods the auger flights become filled with earth and the auger and contained earth then acted as a piston which was forced upward by the hydraulic action of the concrete or grout. More frequently the grout simply follows a spiral course up the auger convolutions and has free escape to the surface where it becomes a handicap to the work and a waste of valuable materials. Such methods entail removal from the hole of a volume of earth substantially equal to the pile volume which must then be hauled away or otherwise disposed of.

My method limits to a minimum the amount of soil excavation and soil-handling, affords opportunity to displace and compress soil to provide high friction and bearing values, reduces the concrete required to make a pile of given capacity, conditions and controls the injected material for formation of a pile with an enlarged bulb whenever soil conditions make such formation of a large bulb possible. A further advantage of my method is that working conditions at the surface of the soil are improved over those of prior methods by eliminating the discharge of objectionable quantities of water, mud and contaminated grout, as usually experienced by other methods.

It will be understood that the apparatus herein described and illustrated is shown for the purpose of illustration only, and the practice of the method is not limited to the use of such apparatus, and, instead, apparatus of other types may be employed as available and as found adapted for different operating conditions.

While the preferred embodiment of my invention has been illustrated and described, it will be understood that changes may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. The method of making concrete piles in situ consisting of the steps of forcing into the earth to approximately the depth of the pile desired an elongated earth penetrating drilling member having a longitudinal passage open adjacent its lower end said member including a tube and helical flights extending for a portion of the length of the tube at its lower part, and withdrawing said member by upward pull thereon to thereby compact the earth around the member above the flight and below the surface and provide a small clearance space therebelow while maintaining a sealed condition within the earth around said member above said space and around said tube immediately above said flights, introducing grout through said passage into said space while maintaining said member stationary until a predetermined pressure resistance to continued supply of grout to said space is encountered, and then continuing to discharge

grout while simultaneously withdrawing said member from the earth by upward pull thereof.

2. The method of making concrete piles in situ consisting of the steps of forcing into the earth to approximately the depth of the pile desired an elongated earth-penetrating drilling member having auger flights at its lower port only and a longitudinal passage open adjacent its lower end and withdrawing said member by upward pull thereon to provide a small clearance space therebelow and simultaneously compact earth around the upper part of said member above said auger flights to maintain a sealed condition within the earth, introducing grout through said passage into said space while maintaining said member stationary until a predetermined pressure resistance to continued supply of grout to said space is encountered, and then continuing to discharge grout under reduced pressure to maintain said sealed condition while withdrawing said member from the earth by pulling the same upwardly.

3. The method of making concrete piles in situ consisting of the steps of forcing into the earth to approximately the depth of the pile desired an elongated earth-penetrating auger member having auger flights at its lower port only and a longitudinal passage open adjacent its lower end, withdrawing said member by pulling the same upwardly to provide a small clearance space therebelow and compact the earth above said auger flights to form a sealing plug around said member, introducing grout through said passage into said space while maintaining said member stationary until a predetermined pressure resistance to continued supply of grout to said space is encountered, then progressively withdrawing said member from the earth by pulling it upwardly and simultaneously supplying grout under pressure, and then supplying the grout substantially without pressure as the lower end of said member approaches the earth surface.

4. The method of making concrete piles in situ consisting of the steps of forcing into the earth to approximately the depth of the pile desired an elongated earth-penetrating auger member having a plain upper tubular port and a longitudinal passage open adjacent its lower end, pulling upwardly said member while within the earth to pack earth around the plain tubular port of said member to effect a seal between the same and the earth therearound, pulling said member upwardly to a position to provide a small clearance space therebelow, introducing concrete through said passage into said space under pressure sufficient to expand said space and compress earth around said space while holding said member at said last named position, and then simultaneously pulling said member upwardly and filling the space therebelow with concrete.

5. The method of making concrete piles in situ consisting of the steps of forcing into the earth to approximately the depth of the pile desired an elongated earth penetrating member having a longitudinal passage open adjacent its lower end and a helical auger flight at its lower end port while confining earth around said member and within the outline of said auger flight, pulling said member upwardly to a partially withdrawn position without rotation thereof to compact earth around said member above said auger flight, forcing concrete through said

passage and into the earth below said member while maintaining said member stationary until a predetermined back pressure develops and then simultaneously pulling said member upwardly in the earth and filling the space therebelow with concrete discharged through said passage.

6. The method of making concrete piles in situ consisting of the steps of rotating an auger having a passage around its lower end portion and a plurality of spiral flights therearound to advance it into the earth to approximately the depth of the piling desired and deeper than the length of said flights, pulling said auger upwardly substantially without rotation to form a compact earth plug above said flights and provide a small clearance space below said auger, forcing concrete through said passage into said space while maintaining said auger substantially stationary until a predetermined back pressure develops, and then progressively withdrawing said auger by pulling it upwardly substantially without rotation and simultaneously filling the space below said auger with concrete discharged through said passage.

7. The method of making concrete piles in situ consisting of the steps of rotating an auger having a passage therethrough and a plurality of auger flights therearound to advance it into the ground to approximately the depth of the piling desired, reversely rotating said auger while maintaining it at said selected depth to pack soil between said flights, partially withdrawing said auger by pulling it upwardly to a pre-determined position providing a clearance space therebelow, discharging concrete under pressure through said passage and into said space to enlarge said space while holding said auger at said predetermined position to prevent flow of concrete to ground level, and then withdrawing said auger by pulling it upwardly substantially without rotation while feeding concrete through said passage substantially at a rate to fill the space below said auger.

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