United States Patent [19]

Godley et al.

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[45] **Jan. 2, 1973**

[54] INSTALLATION OF SAND DRAINS

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[21] Appl. No.: **703,440**

[52] **U.S. Cl.** **61/11**, 61/53.64, 61/53.74, 61/63

[51] **Int. Cl.**.....**E02b 11/00**, E02b 5/34

[58] **Field of Search**.....61/11, 10, 63, 53.52, 53.62, 61/53.6, 53.64, 53.66, 53.74; 175/21

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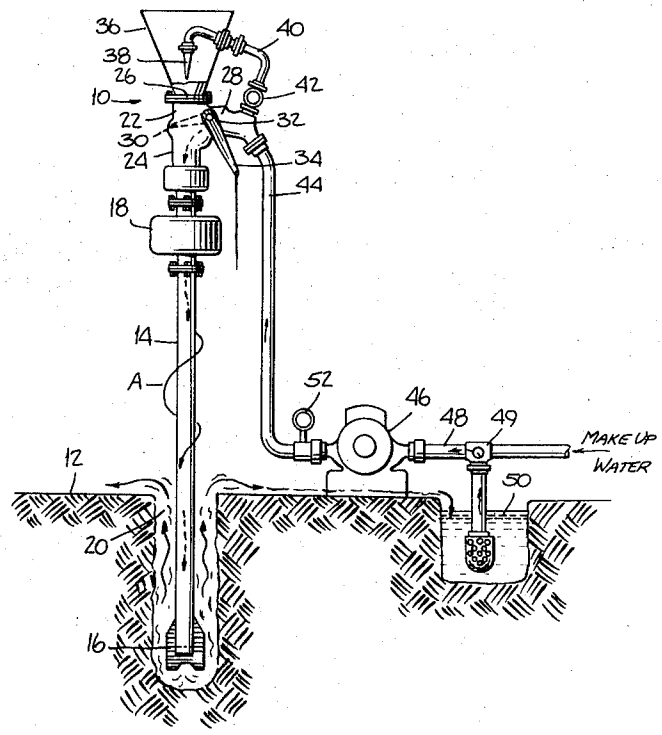
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[57] **ABSTRACT**

Formation of sand drains in the earth by drilling and forcing a fluid at high velocity to wash out a hole and thereafter filling the hole by forcing filler material down through a pipe; the pipe being outfitted with special valve control means to control the flow of fluid and filler therethrough in generally inverse manner.

12 Claims, 19 Drawing Figures



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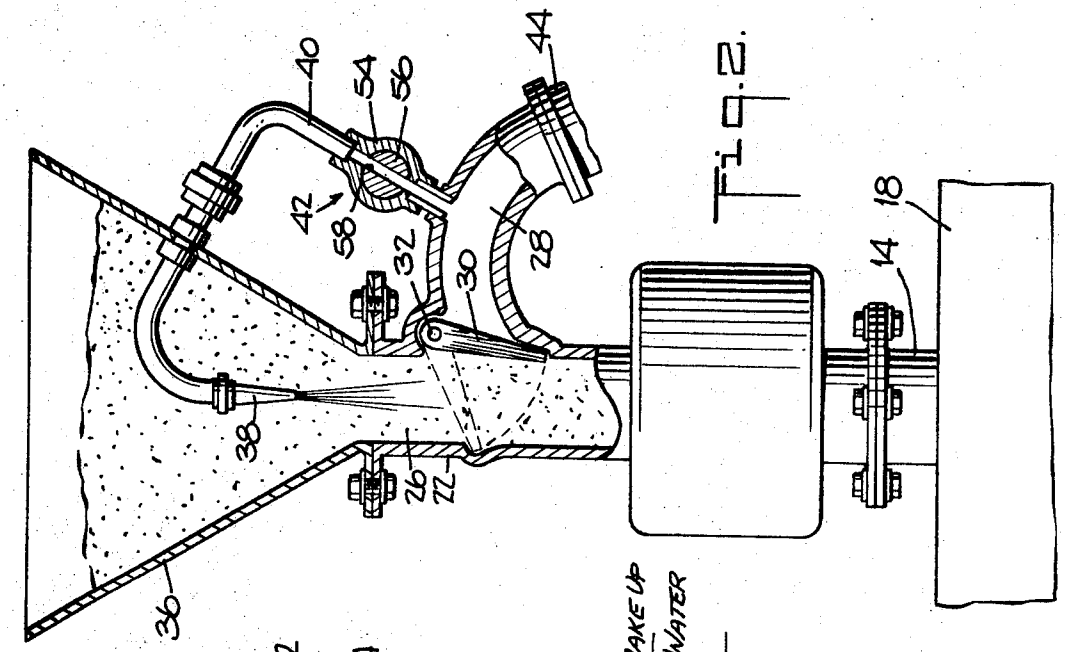


Fig. 2.

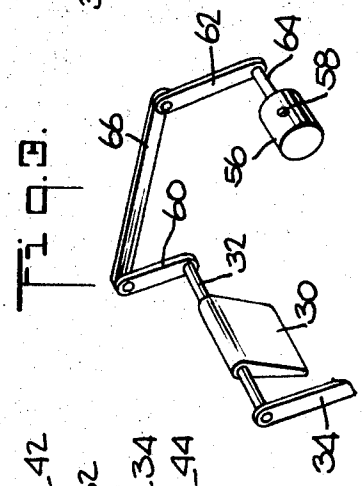


Fig. 3.

Fig. 1.

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Fig. 4.

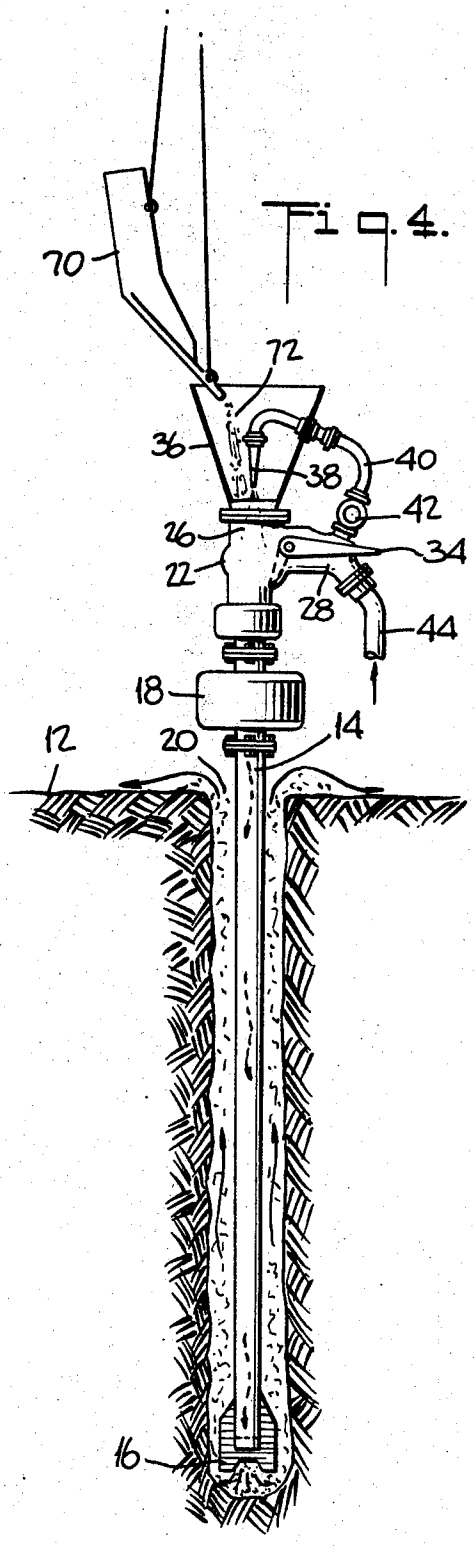
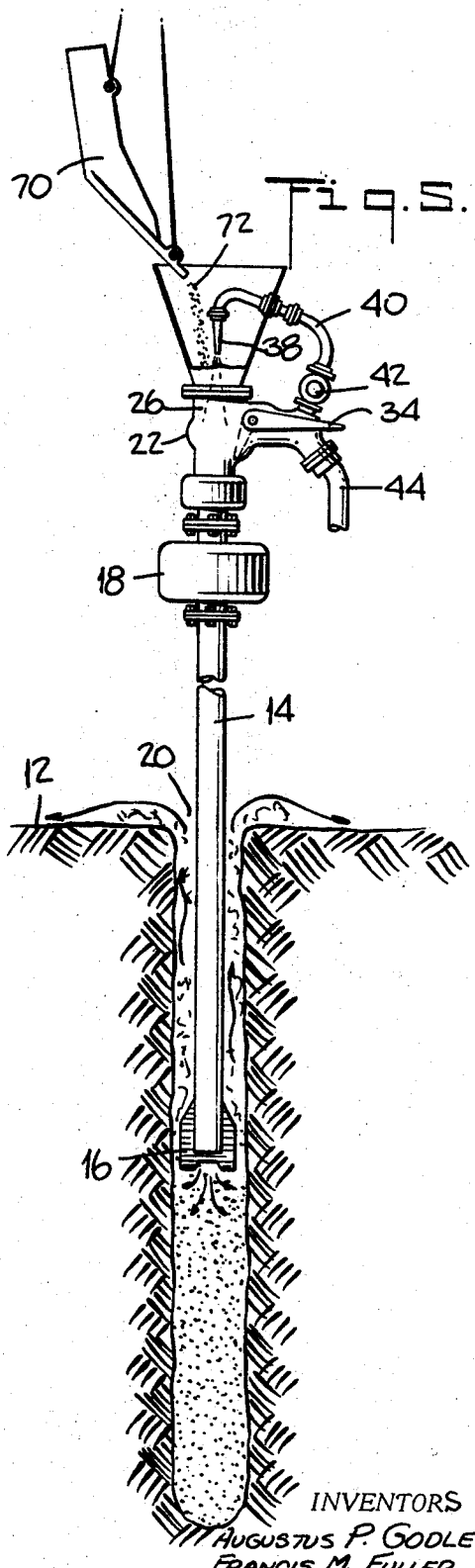


Fig. 5.



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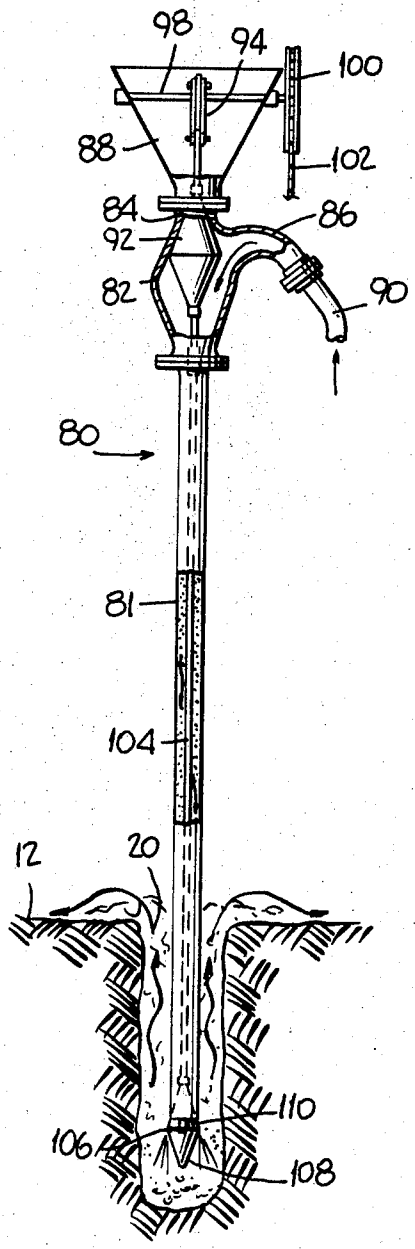


Fig. 6.

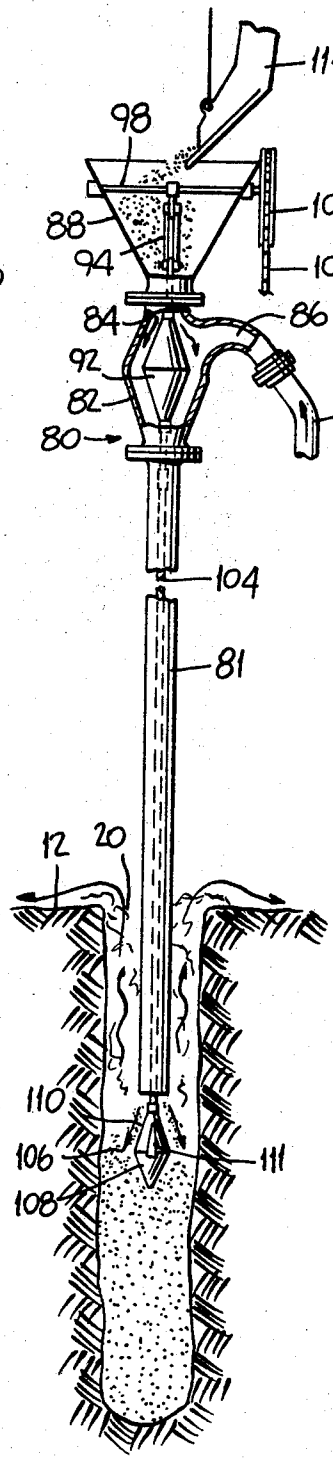


Fig. 7.

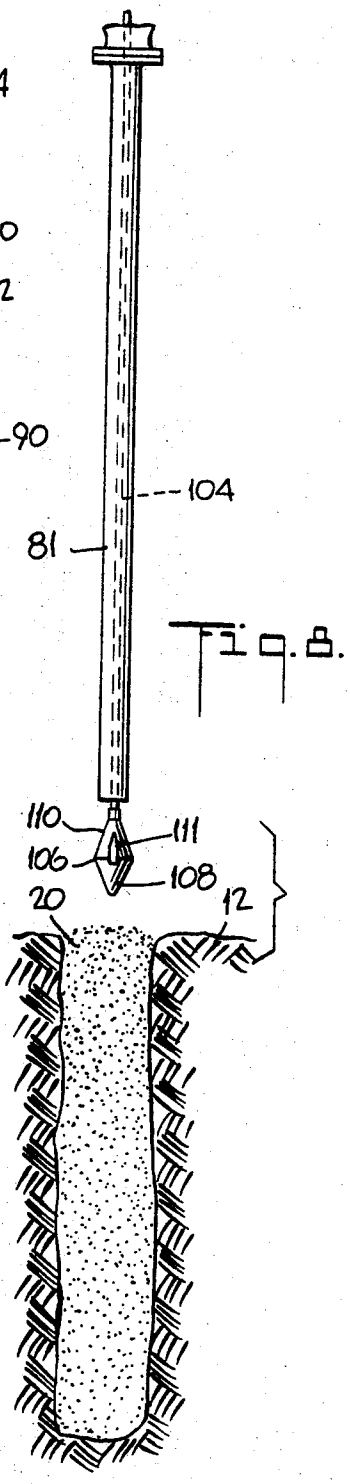


Fig. 8.

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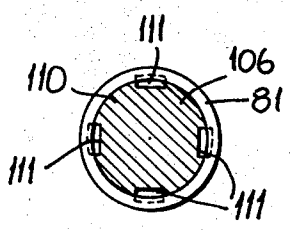


Fig. 12.

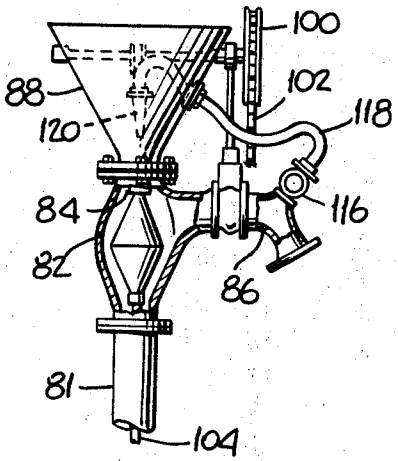


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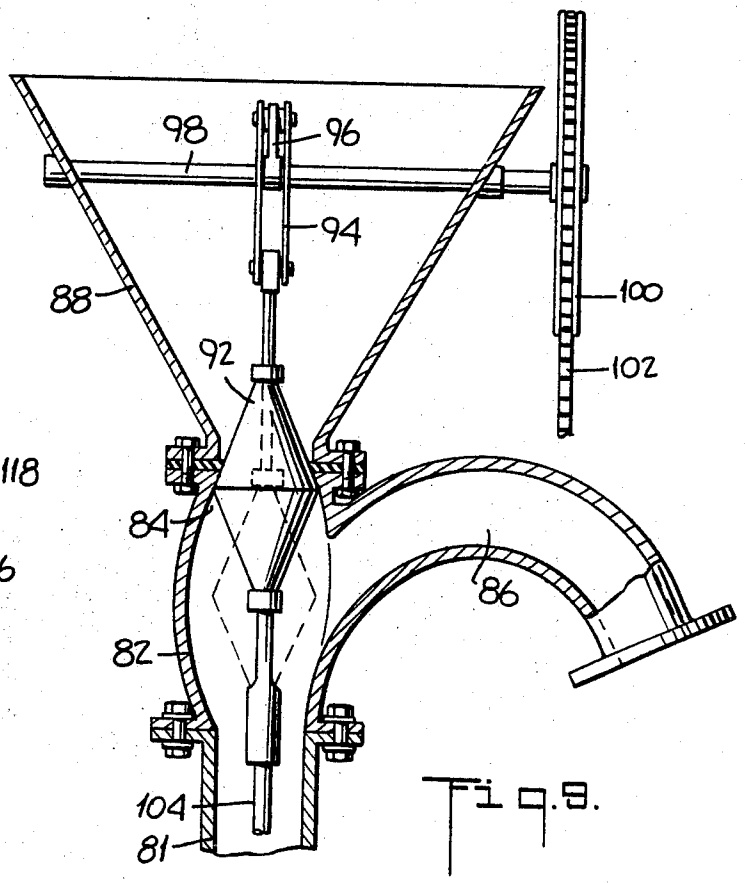


Fig. 9.

Fig. 10.

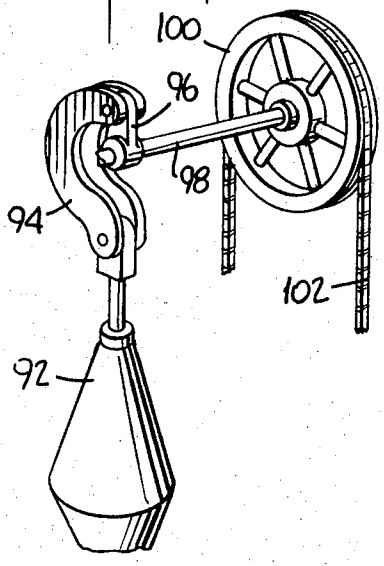
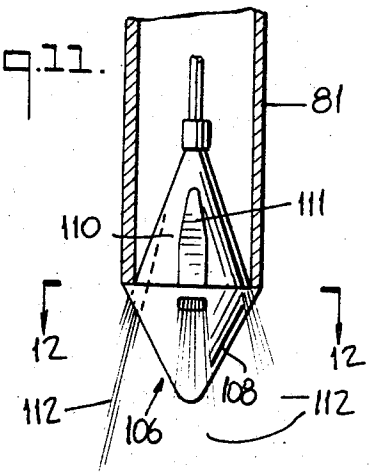
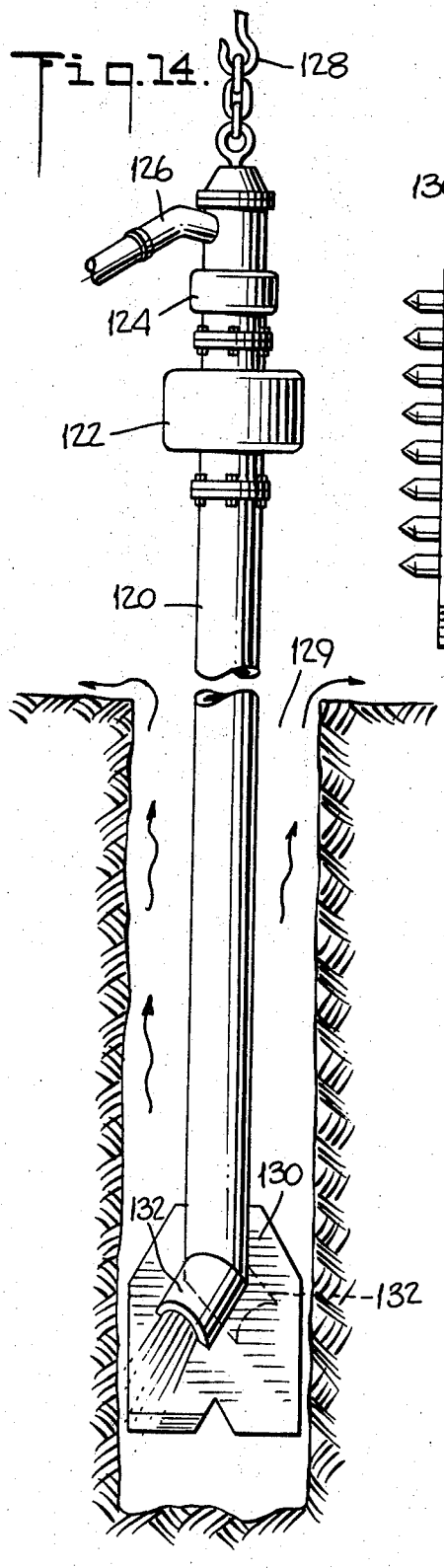


Fig. 11.



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Fig. 14.



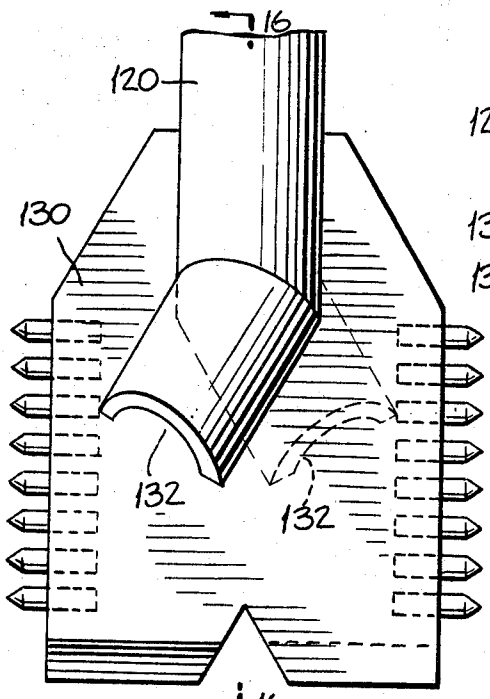


Fig. 15.

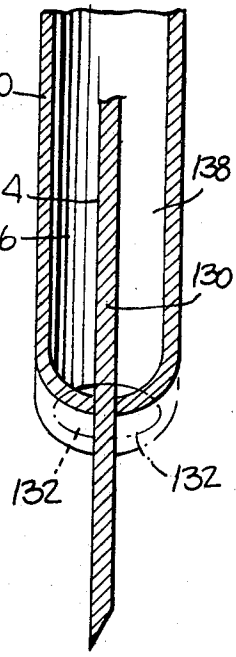


Fig. 16.

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Fig. 17.

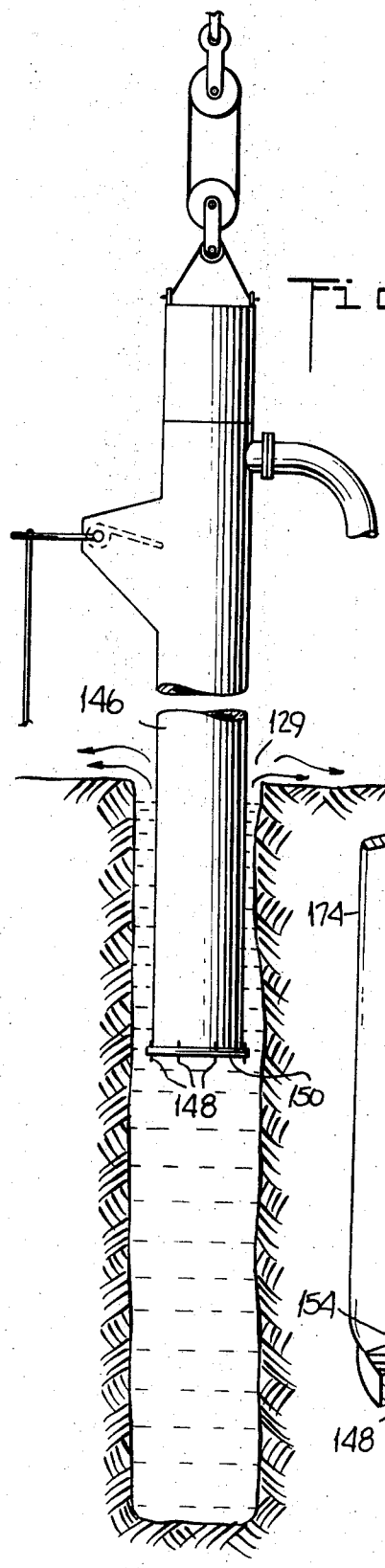


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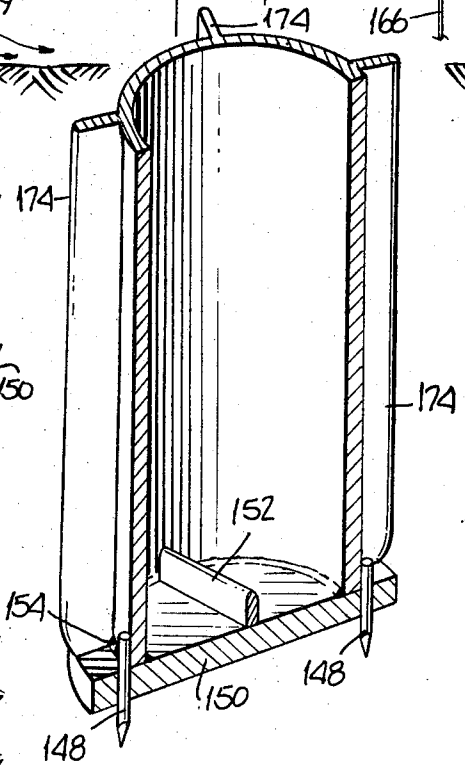
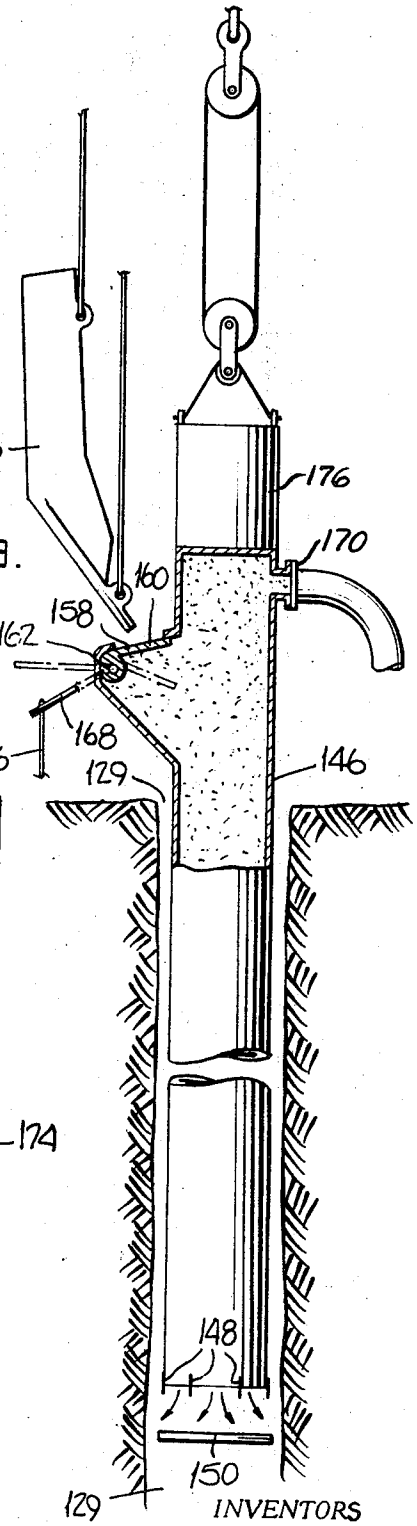


Fig. 19.



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INSTALLATION OF SAND DRAINS

This invention relates to the installation of sand drains and, more particularly, it concerns improvements by which both the effectiveness and economy of sand drain installation are improved.

Sand drains are regions of high water permeability placed artificially in the earth and connected to a region of minimum fluid pressure such as the atmosphere. Essentially, sand drains function to permit relatively rapid water pressure release from locations in the earth where excess water pressures have developed due to construction operations. Excess water pressures in the ground can be built up as a result of the placement of heavy structures or earth fills on the ground, or the driving of pilings into the ground. Because of high excess water pressures the stability of such structures in earth fills may be poor. Furthermore, such structures and earth fills will incur settlements with time as the excess water pressure is gradually dissipated at a rate depending upon the water permeability of the natural soil. By providing regions of high moisture permeability close to these water pressure concentrations it is possible to obtain dissipation of the water pressure effects within a very short time so that a stable condition may be achieved before further construction is undertaken.

Generally, sand drains are constructed by forming a vertical hole in the earth and filling the hole with sand or other moisture permeable material. Actually, it is the hole itself, which is open to the ground surface, that achieves the moisture equalization effects. The sand or other moisture permeable substance however is needed to maintain and to structurally reinforce the vertical hole while at the same time allowing relatively free flow of water to the surface.

Experience has shown that the effectiveness of a sand drain is very dependent upon the manner in which it is built including both the formation of the hole and in the placement of the sand or other material. The generally known hole forming methods utilizing scraping or pounding techniques tend to disrupt the natural earth formation in the vicinity of the peripheral surface of the hole being formed in such a manner that a loss of moisture permeability takes place. Also, if the sand or filler material is not properly placed, areas of overcompactness or underfull may result along the drain hole. Each of these conditions will result in a loss of moisture permeability. In the case of overcompactness, the porosity of the fill becomes decreased; and in the case of underfull, arching may result with voids in the drain hole which will allow cave-ins.

The present invention overcomes the above-described difficulties and permits the installation of effective and reliable sand drains with a minimum of expense and effort.

According to one aspect of the present invention a sand drain is constructed by forming a hole in the earth, flushing the interior of the hole with a fluid to wash out spoil therefrom and to condition its internal surfaces, and then forcing fill material down through a conduit to fill the hole up from the bottom thereof so that the fill material will displace the washing fluid out through the top of the hole.

As hereinafter described in detail, the present invention may be carried out by a simultaneous drilling and washing action whereby a fluid is continually forced down through a conduit into the bottom of the hole at sufficient velocity to carry spoil up with it to the surface of the hole. Sand or fill material may thereafter be carried down the same conduit by fluid moving at a slower rate so that in moving up inside the formed hole it proceeds at a slow enough velocity to allow the fill material to remain at the bottom.

According to a further aspect of the present invention, there is provided novel sand drain formation equipment comprising elements which serve to form and flush out the sand drain hole and also to deposit the fill material therein. This equipment includes an elongated pipe having drilling means at its lower end and means for supplying both water or other fluid and sand or fill into its upper end. Valve means are provided to control the rate of fluid and fill down through the pipe in generally inverse velocity relationship and means are provided to lower and raise the pipe during the drilling and filling phases respectively.

According to a still further aspect of the present invention a sand drain hole is filled with water which is stirred to effect suspension of the drilled earth in the water. Drilling and stirring may be accomplished simultaneously by rotating water jets and a stirring paddle together in the hole. Thereafter, the water and earth suspension is flushed out of the hole. This is achieved by forcing a large displacement element down into the hole, while leaving a small annular clearance about its outer surface to permit the water to rise up around it. The large displacement element may take the form of a hollow tube having an openable bottom sealed to it with a frangible seal. The tube is filled with sand or other sand drain solids, and then air is admitted to the interior of the tube under pressure. This blows open the bottom and allows the sand to flow out into the interior of the hole.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent constructions as do not depart from the spirit and scope of the invention.

Specific embodiments of the invention have been chosen for purposes of illustration and description, and is shown in the accompanying drawings forming a part of the specification, wherein:

FIG. 1 is a side elevational view illustrating a system for forming sand drains according to the present invention;

FIG. 2 is an enlarged fragmentary view, partially in section, illustrating an upper portion of the system of FIG. 1;

FIG. 3 is a perspective view illustrating a valve interconnection linkage system utilized in the system of FIG. 1;

FIGS. 4 and 5 are views illustrating sand drains forming system of FIG. 1 during intermediate and final stages of a sand drain forming operation;

FIG. 6 is a side elevational view of a sand drain forming system forming a second embodiment of the present invention;

FIGS. 7 and 8 are views illustrating the sand drain forming system of FIG. 6 during intermediate and final stages of a sand drain forming operation;

FIG. 9 is an enlarged fragmentary view, partially in section of the upper portion of the system of FIG. 6;

FIG. 10 is a perspective view illustrating a control valve arrangement used in the system of FIG. 6;

FIG. 11 is an enlarged fragmentary view of the lower portion of the system illustrated in FIG. 6;

FIG. 12 is a sectional view taken along lines 12—12 of FIG. 11;

FIG. 13 is a fragmentary view similar to FIG. 9, but showing a modification thereof;

FIG. 14 is a side elevational view of a sand drain drilling arrangement according to a further modification;

FIG. 15 is an enlarged front elevational view of the bottom portion of the drilling arrangement of FIG. 14;

FIG. 16 is a side elevational view of the bottom portion shown in FIG. 15;

FIG. 17 is a side elevational view of a portion of a sand drain flushing arrangement according to a further modification;

FIG. 18 is a perspective view of the lower end of the flushing arrangement of FIG. 17; and

FIG. 19 is a side elevational view of the upper portion of the flushing arrangement of FIG. 17.

As illustrated in FIG. 1, a sand drain forming system, illustrated generally at 10, is set up on a ground surface 12 into which a sand drain is to be formed. The system 10 includes an elongated vertical pipe 14, at the lower end of which are provided mechanical cutting bits 16. A rotary drive mechanism 18 is coupled to the upper end of the pipe 14 to cause it to rotate in the direction of an arrow A. Means, not shown, are provided to lower the rotating pipe 14 downwardly into the earth. As the pipe 14 rotates the cutting bits 16 break away chunks of earth thereby forming a vertical hole 20. The broken away chunks of earth are removed in a manner to be described.

Immediately above the drive mechanism 18, there is provided a valve housing 22 having a lower outlet 24 which communicates through the drive mechanism 18 to the interior of the pipe 14. The housing 22 additionally is formed with an upper sand inlet region 26 and a lateral fluid inlet region 28.

As shown in FIGS. 1 and 2 there is provided a flapper valve member 30 which is pivotally mounted within the housing 22 in such a manner that it alternately closes off and opens the upper sand inlet region 26 and the lateral fluid inlet region 28.

The flapper valve member 30 is mounted on the housing 22 by means of an axle 32. A crank arm 34 is also connected to the axle 32 exteriorly of the housing 22 for actuating the flapper valve 30.

A sand hopper 36 is mounted immediately above the sand inlet 28 and serves to guide sand down via the inlet 26 and the housing 22 into the pipe 14 when the flapper valve 30 is in its lowermost position as illustrated in FIG. 2. A flushing nozzle 38 is mounted centrally within the hopper 36 and points downwardly towards the sand inlet region 26 of the housing 22. The flushing nozzle 38 is secured to the side of the hopper 36 by means of a conduit 40 which in turn is connected via a fluid control valve 42 to the fluid inlet region 28 of the housing 22. The fluid inlet region 28 in turn is connected by means of a fluid conduit 44 to a pump 46. The inlet of the pump 46 is connected via an inlet conduit 48 to a T-connection 49 from which it receives fresh makeup water from an external source (not shown) and recycled water from a sump 50 located closely adjacent the hole 20. A fluid pressure gage 52 is mounted at the output side of the pump 46 to provide an indication of the amount of fluid flow being utilized by the system.

As shown in FIG. 2 the fluid supplied by the pump 46 passes up through the fluid conduit 44 and into the fluid inlet region 28 of the housing 24. A portion of this fluid also passes through the flushing control valve 42, the flushing fluid supply line 40 and down through the flushing nozzle 38 located in the hopper 36. The flow of fluid through the flushing nozzle is controlled by means of the flushing fluid control valve 42. As shown in FIG. 2 this valve comprises a housing 54 within which a cylindrical valve element 56 rotates. The valve element 56 has an internal passage 58 therethrough which, when aligned with the flushing fluid conduit 40 and the fluid inlet region 28, as shown in FIG. 2, permits the passage of flushing fluid to the nozzle 38. On the other hand, when the valve element 56 is rotated so that its internal passage 58 goes out of alignment with the inlet region 28 and the flushing fluid conduit 40, the flow of fluid through the flushing nozzle 38 is stopped.

Turning now to FIG. 3, it will be noted that the flapper valve element 30 and the flushing fluid control valve 56 are interconnected by means of a linkage mechanism which includes a pair of link arms 60 and 62 each connected at one end to one of the shafts 32 and 64 on which the valve elements are mounted. An interconnecting link 66 pivotally interconnects the other end of each of the two link arms 60 and 62. The mechanism comprising the links 62 and 66 serves to coordinate the movement of the valve members 30 and 56 in such manner that when the flapper valve member 30 is in its upper position closing off the upper sand inlet 56 (as shown in FIG. 1) the flushing fluid valve element 56 is in a position such that it also closes off the flow of fluid through the flushing conduit 40 to the flushing nozzle 38. Conversely, when the flapper valve element 30 is in its downward position as shown in FIG. 2 closing off the fluid inlet region 28, the flushing fluid valve member 56 is moved to a position permitting the flow of fluid through the flushing conduit 40 to the flushing nozzle 38. This fluid then flows downwardly together with the sand in the hopper 36 down through the housing 22 and the pipe 14.

Operation of the above-described system to form a sand drain is illustrated sequentially in FIGS. 1, 4 and 5. As shown in FIG. 1, the hole 20 is first formed in the earth by operation of the drive mechanism 18 which rotates the pipe 14 so that mechanical bits 16 dig into the earth as the entire assembly is lowered. During this time, the flapper valve 30 is in its upper position as shown in FIG. 1, thereby preventing the flow of sand or

fluid down through the hopper 36 and into the pipe 14. However during this time, the flapper valve 30, as shown in FIG. 2, opens the fluid inlet region 28 so that the pump 46 may supply fluid continuously and in large quantities down through the interior of the pipe 14. As illustrated in FIG. 1, the rapid flow of fluid down through the pipe 14 causes the cut away particles of earth or spoil to be washed upwardly toward the top of the hole 20 so that a continuous washing action is effected along the walls of the hole 20.

The liquid and spoil slurry which is washed up out of the hole 20 flows along the surface 12 back into the sump 50 where the solid particles are permitted to settle. The liquid itself however, may be reused in the washing and flushing operation. Accordingly it is pumped back via the T-element 49 to the inlet side of the pump 46. As indicated previously, additional makeup water may be supplied via the other arm of the T-element 49.

When the hole 20 has been formed to a desired depth and the system reaches the position shown in FIG. 4, the drive mechanism 18 is stopped and the valve arrangement is actuated so that the flapper valve member 30 moves to its lowermost position as shown. In this position, the flapper valve member 30 closes off the flow of fluid through the lateral inlet region 28. At the same time it opens the upper inlet region 26 to the hopper 36. When this takes place, a sand skip 70 is lifted to a position above the hopper 36 by suitable means (not shown) and is caused to dump a load of sand 72 into the hopper 36.

During the dumping of sand down into the hopper 36 the flushing fluid control valve 42 is in a position such that fluid from the pump 46 flows through the flushing conduit 40 and down through the flushing nozzle to wash the sand from the hopper down through the pipe 14 so that it is deposited in the bottom of the hole 20.

It will be noted that the diameter of the flushing conduit 40 is considerably restricted with respect to the diameter of the fluid supply conduit 44. Thus the flow rate of fluid through the pipe 14 from the flushing nozzle 38 during the depositing operation is considerably less than the flow rate which takes place via the fluid inlet region 28 during the digging operation. As a result of this lessened flow rate, the fluid velocity at the bottom of the hole 20 is insufficient to wash the deposited sand back up to the surface 12 of the earth. Accordingly, the sand is carried down through the interior of the pipe 14 and is left to remain in the hole 20. It has been found that the use of continuously flowing fluid, both to achieve a flushing action during the digging operation and to carry sand to the bottom of the hole during the depositing operation, results in the provision of a sand drain which is especially effective in permitting the free drainage of liquid from the surrounding earth. There is no undue compaction of the earth in the vicinity of the sand drain, and the surfaces of the sand drain, i.e., the earth-sand interface is smooth; and free-flow transition is provided for the liquid in this region.

The arrangement shown in FIGS. 6—12 utilizes a high velocity water jet arrangement for the digging operation. As shown in FIG. 6, there is provided a sand drain forming system, illustrated generally at 80, which includes an elongated pipe 81 and a housing 82 fitted to the top of the pipe. The housing 82 includes an upper sand inlet region 84 and a lateral fluid inlet region 86. A sand hopper 88 is mounted on top of the upper sand inlet region 84 to direct sand into the housing when the region 84 is opened. Fluid supply means (not shown) are provided to supply fluid via an inlet pipe 90 to the lateral fluid inlet region 86.

Inside the housing 82 there is provided a plug type valve member 92 which moves in a vertical direction between an upper position, as shown in FIG. 6 and a lower position as shown in FIG. 7. In its upper position, the valve member 92 fully closes the upper sand inlet region 84 and fully opens the fluid inlet region 86. In its lower position the valve member 92 fully opens the upper sand inlet region 84 and partially closes the fluid inlet region 86.

As can be seen in FIGS. 9 and 10, the plug type valve member 92 is connected at its upper end through a pivotal link 94 to one end of a crankarm 96. The other end of the crankarm 96 is mounted on a crankshaft 98 which in turn extends through, and is supported horizontally for rotation by, the walls of the sand hopper 88. The outer end of the crankshaft 98 is provided with a pulley or sprocket 100 about which a belt or chain 102 is looped. This belt chain is pulled by manual or automatic means (not shown) to rotate the crankshaft 98 and change the vertical position of the valve member 92.

As shown in FIG. 6, the lower end of the valve member 92 is connected via a rod 104, inside the pipe 81 to a jet forming nozzle control element 106. This element is moved up and down with the valve member 92; and in its upper position, as shown in FIG. 6, the nozzle control element cooperates with the lower edge of the pipe 81 to form high velocity jet nozzles. In its lower position, as shown in FIG. 7 the nozzle control element 106 allows sand and water to flow freely and at relatively low velocity out from the bottom of the pipe 81.

The construction of the jet forming nozzle control element 106 is best shown in FIGS. 11 and 12. It will be seen that this element includes an outer conically shaped tip portion 108 and an inner conically shaped plug portion 110. A plurality of longitudinally extending channels 111 are formed along the outer surfaces of both portions of the element; and when the element is in its upper or restricted position as shown in FIG. 11, these channels cooperate with the lower edge of the pipe 81 to define low cross section, high velocity jet nozzles. These nozzles serve to control the flow of water out from the bottom of the pipe 81 so that it proceeds in the form of sharply defined streams 112 of high velocity. These streams are directed at the surrounding earth at the bottom of the hole being dug; and they simultaneously break up and wash away the earth in this region. The flow rate of the water in the streams 112 is maintained at a valve sufficient to carry the washed away earth up to the top of the hole 20.

When the jet forming nozzle control element is moved to its lower position, its inner conically shaped plug portion 110 moves away from the lower edge of the pipe 81 to define a greatly enlarged outlet cross section through which water and sand may pass at a relatively high flow rate but at a much reduced linear velocity.

In operation, the system of FIGS. 6–12 undergoes the same overall sequence as described in connection with the system of FIGS. 1-5. Thus there is provided a simultaneous digging and washing operation, followed by a fluid conveyor type depositing operation. During the digging operation, the valve member **92** and the nozzle control element **106** are in their uppermost positions as shown in FIG. **6**. Thus no sand is permitted to flow down through the hopper **88** during this time. On the other hand the lateral fluid inlet region **86** is fully opened and a large fluid flow proceeds down through the pipe **81**. This fluid flow is converted by the restricted nozzle control element **106** into high velocity jet streams **112** which dig out and wash away particles of earth from the bottom of the hole **20**.

When the hole **20** is formed to the desired depth, the belt or chain **102** is pulled to turn the pulley or sprocket **100** thereby rotating the crankshaft **98** and causing the crankarm **96** to move the pivotal link **94** so that the valve member **92** and the jet forming nozzle control element **106** are moved to their lowermost positions as shown in FIG. **7**. At this time sand is dumped into the hopper **88** from a skip **114**. With the valve member **92** and the nozzle control element **106** in their lowermost positions, sand flows freely downwardly from the hopper **88** through the valve housing **82** and the pipe **81** and out past the nozzle control element **106**. This downward flow of sand is aided by the reduced but still substantial flow of water which the valve member **92** permits to flow in via the lateral fluid inlet region **86** in the housing **82**. This fluid flow, while sufficient to convey sand down to the bottom of the hole **20**, is insufficient to carry it back up to the top of the hole. Thus, the sand is evenly and smoothly deposited in the hole and eventually fills it as shown in FIG. **8**. Of course, the sand drain forming system **80** which was gradually lowered during the digging operation, is raised during the depositing operation.

FIG. **13**, shows a modification to the system of FIGS. **6–12** wherein there is provided a fluid control valve **116** connected to the lateral fluid inlet region **86** of the valve housing **82**, and a flushing conduit **118** leading from the valve **116** through the wall of the hopper **88** to a flushing nozzle **120** which is aimed down into the bottom of the hopper. This arrangement serves to provide an additional flushing during the depositing operation to assist in moving sand down from the hopper **88** and into the pipe **81**.

FIGS. **14–19** illustrate a still further modification of the present invention. As shown in FIG. **14** there is provided an elongated hollow rotary drill pipe **120** which is rotated continuously by means of a rotary drive mechanism **122**. A water tight swivel joint **124** is provided immediately above the rotary drive mechanism and is connected via an inlet hose **126** to a supply of pressurized water (not shown). The water supplied via the hose **126** passes through the swivel joint **124** and down through the rotating drill pipe **120**. The entire assembly is supported by means of a hook **128** which can be controlled to lower and raise the assembly into and out of a hole **129** being cut into the earth.

At the lower end of the drill pipe **120** there is provided a stirring paddle **130** and a pair of cutting jets **132**. As shown in FIGS. **15** and **16**, the stirring paddle **130** simply comprises a flat plate fitted up into a longitudinal slot **134** in the bottom of the rotary drill pipe **120**. The paddle **130** divides the lower interior of the pipe **120** into two separate channels **136** and **138**; and these channels lead out to individual water jet openings **140** and **142** located on opposite faces of the paddle **130**.

As the rotating drill pipe **120** is lowered into the hole **129**, pressurized water is forced out of the jet openings **140** and **142** and cuts into the earth. The size of the hole thus cut depends upon the size of the jet openings, the water pressure used, and the rotational and longitudinal speed of the assembly. These variables are chosen however such that the hole which is cut is of a larger diameter than the distance across the paddle **130**. This ensures that the paddle will not "wipe" the sides of the hole and thus impair its efficiency as a sand drain. The purpose of the paddle is to keep the loosened material being dug in a stirred up condition and thereby maintained in a suspended state in the water so that it may thereafter be washed out of the hole along with the water.

From time to time soil conditions will be encountered which will not allow penetration by the water jets. In such case the paddle **130** may be provided with a plurality of outwardly protruding teeth **144** which, during rotation, will tend to scratch or scarify the sides of the hole. This action will weaken the earth and permit the water jets to do sand actual cutting, thereby avoiding the wiping action which results from the use of blade type bits.

After the hole in the earth has been formed to the desired depth, the rotary drill pipe **120** and its associated cutting elements are withdrawn. Thereafter, as illustrated in FIG. **17**, a sand drain tube **146** is lowered rapidly into the hole **129**. The sand drain tube **146**, as shown in FIG. **18** is a hollow steel pipe having an outer diameter slightly less than the diameter of the hole **129**. Around the lower edge of the tube **146** there are welded a plurality of downwardly projecting pointed bars **148**. An expendable bottom plate **150**, of wood or similar material is hammered onto the bottom of the tube **146** and is held in place by the pointed bars **148**. A cross bar **152** is welded diametrically across the lower end of the tube **146** to provide reinforcement for the bottom plate **150**. A sealing compound **154**, e.g., roofing slate or the equivalent, is applied to seal the bottom plate to the tube.

Reverting to FIG. **17**, it will be seen that as the tube **146** with its bottom plate **150** is forced rapidly down into the hole **129**, it produces a large displacement of the water and earth suspension in the hole and causes it to rush rapidly upwardly up and out from the hole. This high velocity upward movement of water causes it to carry with it, the cuttings previously made by the water jets and previously put into suspension by the stirring action of the paddle **130**. The rapid upward movement of water along the sides of the hole **129** also produces a washing action which serves to clean the surfaces of the hole. This improves the porosity in the vicinity of the hole and enhances its ability to transmit water from the surrounding earth.

When the tube **146** is fully inserted into the hole **129**, it is filled with sand as indicated in FIG. **19**. As there shown, sand is poured from a sand skip **156** and into the tube **146** through a sand opening **158** formed near

its upper end. The sand opening **158** is provided with an airtight door **160** mounted on a pivot **162**. The opening and closing of the door may be controlled by means of a line **164** attached to an arm **168** extending out from the door on the opposite side of the pivot **162**. serves as

When the door **160** is closed the interior of the tube **146** is pneumatically sealed. Thereafter, air which is pressurized to about 100 pounds per square inch is admitted to the interior of the tube **146** via an air connection **170** also located near the top of the tube. Because of the porosity of the sand filling in the tube this air pressure is communicated throughout the tube and is applied to the bottom plate **150**. The air pressure is sufficient to blow the bottom plate off as indicated in FIG. **19**. As a result, the sand within the tube flows out into the hole **129**. The action of the pressurized air at this point serves to "lubricate" the individual sand particles, permitting the tube **146** to be removed while at the same time properly placing the sand in the drilled hole. As the tube **146** is withdrawn from the hole the air pressure is reduced so a s to prevent "blowing" of the top of the thus completed sand drain.

In cases where it is believed that the tube **146** might tend to rub against one side or the other of the hole **129** either when it is being pushed down into the hole or while it is being withdrawn, the tube may be provided with a series of longitudinal ribs **172** as shown in FIG. **18**. These ribs will center the casing in the drilled hole while reducing the wiped (and possibly smeared) area to a minimum.

A massive weight **174** as shown in FIG. **19** may be provided at the upper end of the tub **146** to assist in forcing it down into the hole **129** against the opposition of the water being forced out of the hole.

Having thus described the invention with particular reference to the preferred forms thereof, it will be obvious to those skilled in the art to which the invention pertains, after understanding the invention, that various changes and modifications may be made therein without departing from the spirit and scope of the invention, as defined by the claims appended thereto.

What is claimed is:

1. A method of forming a sand drain in the earth which comprises the steps of drilling a hole in the earth, introducing a fluid into said hole to substantially fill said hole, causing said fluid to flow over and wash spoil out through the top of said hole, and thereafter forcing drain solids down through a pipe in the hole to fill same up from the bottom thereof, thereby to displace said fluid out through the top of said hold, said solids being forced down into said hole by making a slurry thereof with fluid and washing same down through a pipe, the fluid velocity being maintained below that which will carry said solids up to the top of said hole.

2. A method as in claim **1** wherein said fluid is forced into said hole during said drilling to provide simultaneous drilling and washing.

3. A method as in claim **1** wherein said fluid is forced into the bottom of said hole in the form of high velocity jet sprays to effect said drilling.

4. A method as in claim **1** wherein said during said overflow at least a portion of said fluid is recovered and used for further washing.

5. A method as in claim **4** wherein said fluid is caused to pass out of the top of said hole into a settling sump where washed out spoil may settle and wherein said portion of said fluid is thereafter pumped back into said hole.

6. A method as in claim **1** wherein said fluid is forced into said hole from the bottom thereof.

7. A method of forming a sand drain in the earth which comprises the steps of drilling a hole in the earth, filling said hole with water, stirring the water in the hole to suspend the drillings, rapidly forcing a large displacement element having a cross section smaller than the hole down into it, thereby to produce rapid upward movement of water from the hole to carry with it the suspended drillings, and thereafter filling the hole with sand drain solids.

8. A method as in claim **7** wherein said large displacement element is forced down the center of the hole to direct the upward flow of water along the hole surfaces, thereby to achieve a washing action along said surfaces.

9. A method as in claim **7** wherein said large displacement element is a hollow elongated tube and wherein sand drain solids are admitted to said hole via said tube.

10. A method as in claim **9** wherein said tube is provided with an openable bottom element sealed thereto with a frangible seal and wherein following admission of sand drain solids to said tube and insertion of said tube into said hole pressurized air is admitted to said tube to blow open said bottom and release said sand drain solids.

11. A method as in claim **7** wherein said drilling and stirring are achieved simultaneously by the rotation of earth cutting water jets.

12. A method as in claim **11** wherein a paddle element is rotated with rotation of said jets.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,707,847 Dated January 2, 1973

Inventor(s) GODLEY et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, lines 45 and 49, "underfull" to read --underfill--;

Column 8, line 4, for "individual water jet openings 140 and 142" to read --the openings of the water jets 132--;

line 11, for "jet openings 140 and 142" to read --water jets 132--;

line 28, delete the word "sand";

line 45, for "e.g. roofing" read --e.g. of the type used for roofing--;

Column 9, line 4, for "means of a line 164" to read --means of a line 166--;

line 22, for "so a s" to read --so as--;

line 28, for "172" to read --174--;

line 31, for "174" to read --176--;

line 32, for "tub" to read --tube--;

line 46, for "fluid" to read --liquid--;

lines 46 and 47, for "to substantially fill said hole, causing said fluid" to read --at a first rate sufficient--;

line 51, for "fluid" to read --liquid--; for "hold" to read --hole--;

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,707,847 Dated January 2, 1973

Inventor(s) GODLEY et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page 2 - continued

Column 10, line 2, for "fluid and" to read --said liquid--;

lines 2 and 3, for ", the fluid velocity being maintained" to read --while the liquid is flowed at a second, lesser, rate--;

lines 5, 8 and 12, for "fluid" to read --liquid--;

line 11, for "said during said" to read --during--;

lines 14, 17 and 19, for "fluid" to read --liquid--;

Signed and sealed this 27th day of November 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

1973

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