United States Patent

Harmstrof

[15] **3,688,511**

[45] **Sept. 5, 1972**

[54] **METHOD OF AND APPARATUS FOR FLUSH-JET EMBEDDING STRUCTURAL ELEMENTS AND FOR SUCKING OFF GROUND MATERIAL**

[72] Inventor: **Rudolf Harmstrof,** Schillerstr. 45, Hamburg-Altona, Germany

[22] Filed: **July 8, 1970**

[21] Appl. No.: **53,189**

[30] **Foreign Application Priority Data**

Aug. 18, 1969 Germany.....P 19 41 993.3

[52] **U.S. Cl.** **61/72.4,** 37/41, 37/62, 239/311, 239/318, 239/434.5

[51] **Int. Cl.**.....**E02f 5/00,** B05b 7/28

[58] **Field of Search** 61/72.4, 72.3, 53.74; 37/41, 37/62, 63, 78; 239/434.5, 433, 311, 318

[56] **References Cited**

UNITED STATES PATENTS

3,338,060	8/1967	Harmstorf	61/72.4
1,698,515	1/1929	Stewart	37/78
1,660,557	2/1928	Heimburger	239/434.5
3,187,447	6/1965	Hollyoak	37/78
3,188,009	6/1965	Miscovich	239/434.5 X

Primary Examiner—Jacob Shapiro
Attorney—Beaman & Beaman

[57] **ABSTRACT**

The method of the invention consists in directing a jet of a mixture of water and air into the ground whereby the ground material is loosened and removed. A ditch is formed in this way and an element is laid into the ditch. The apparatus for performing this method has water jet pumps arranged at the side adapted to penetrate into the ground. The method and apparatus are especially suited for laying cables and pipes in a water bed.

4 Claims, 6 Drawing Figures

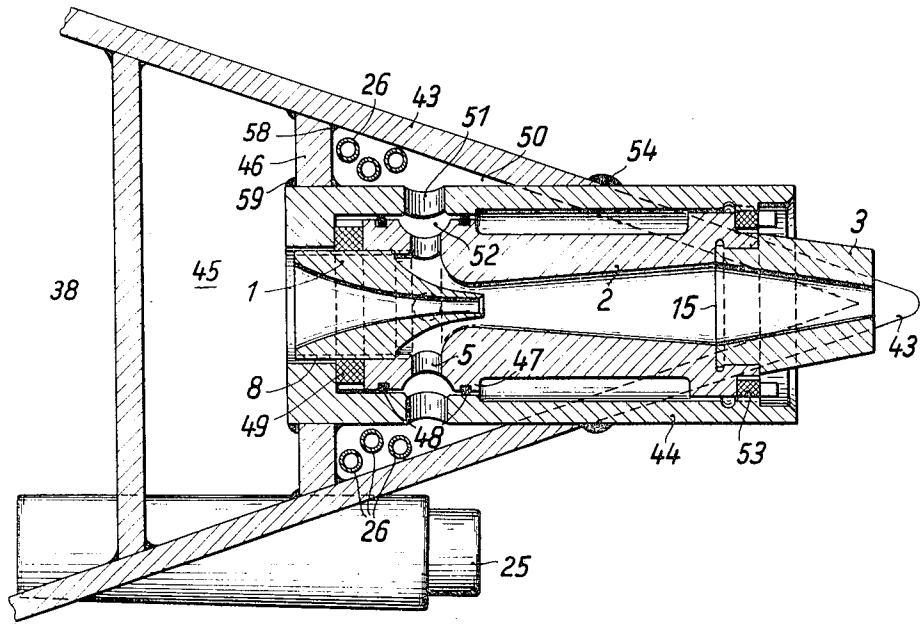
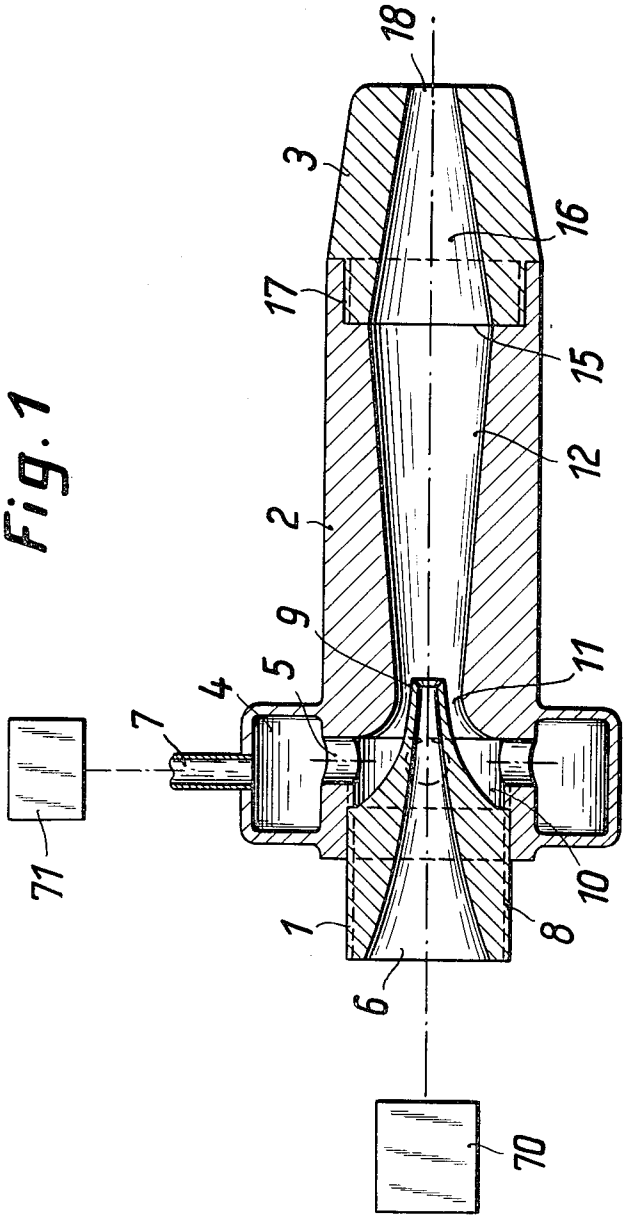
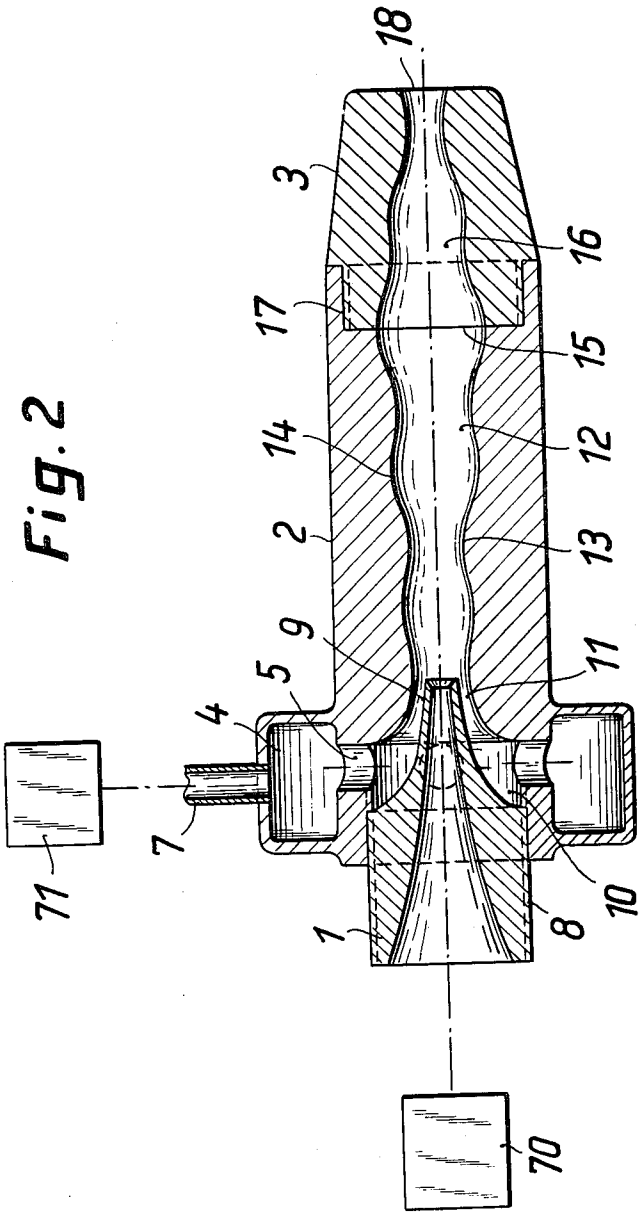


Fig. 1



INVENTOR
Rudolf Hormetorf
BY
Beaman & Beaman
Attys

Fig. 2



INVENTOR
Rudolf Harnisdorf
BY
Beaman & Beaman
Attys

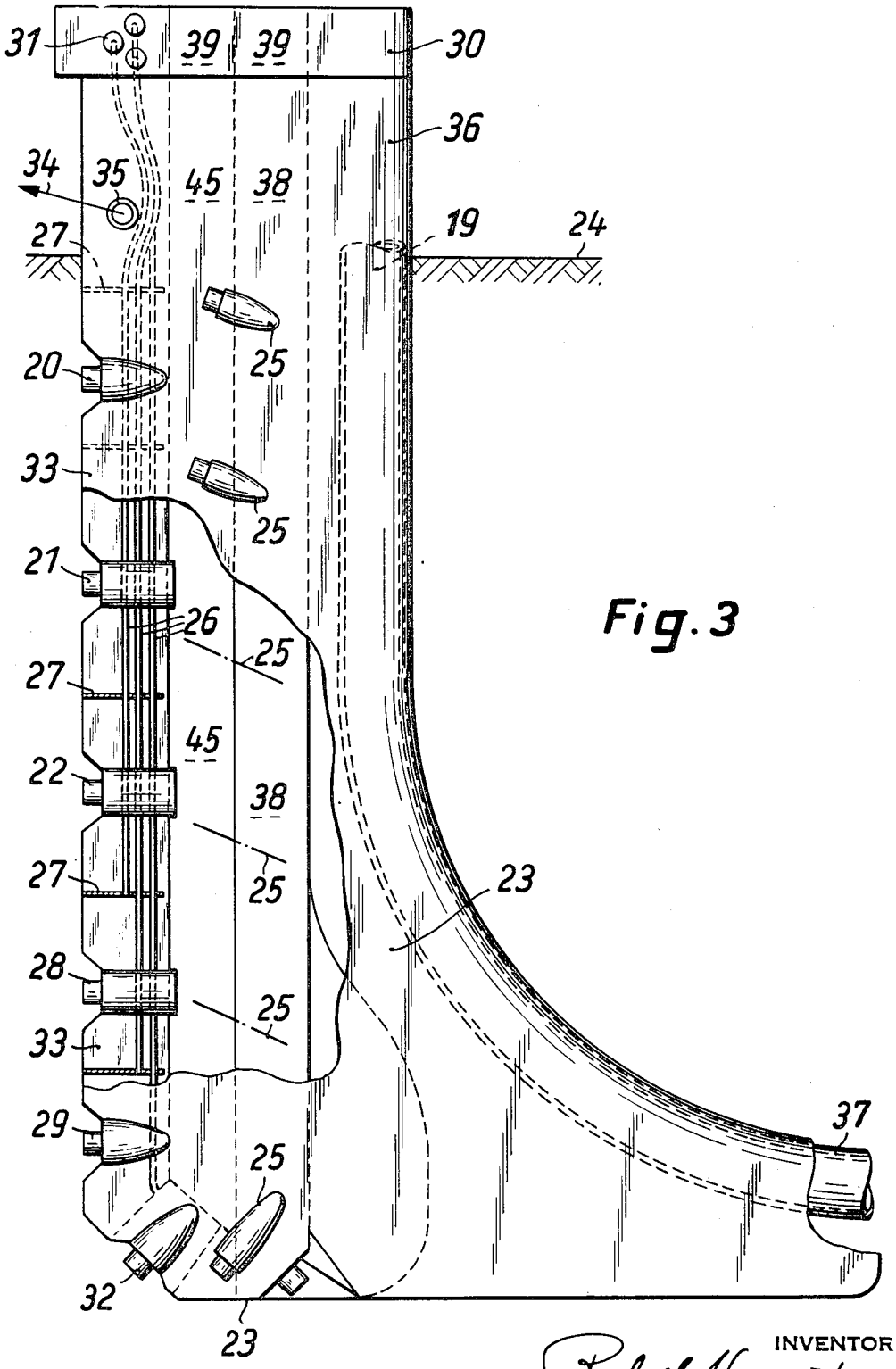
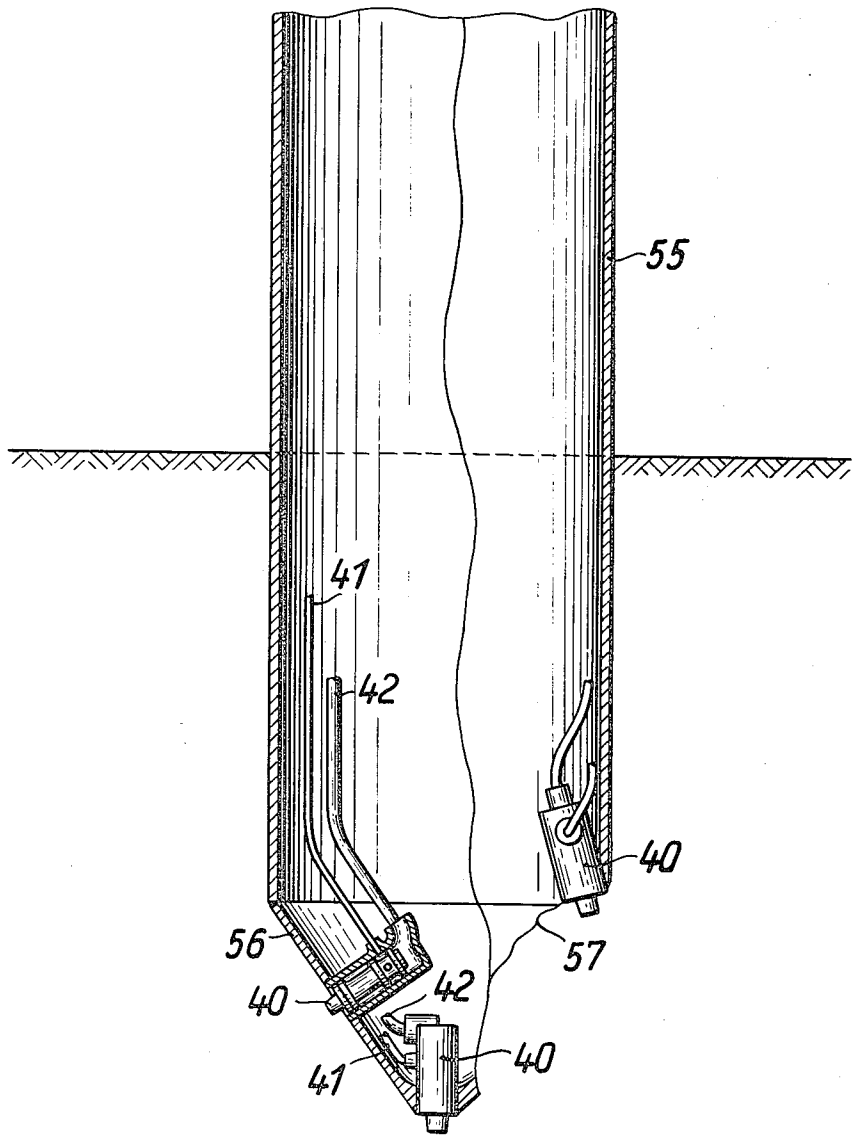


Fig. 3

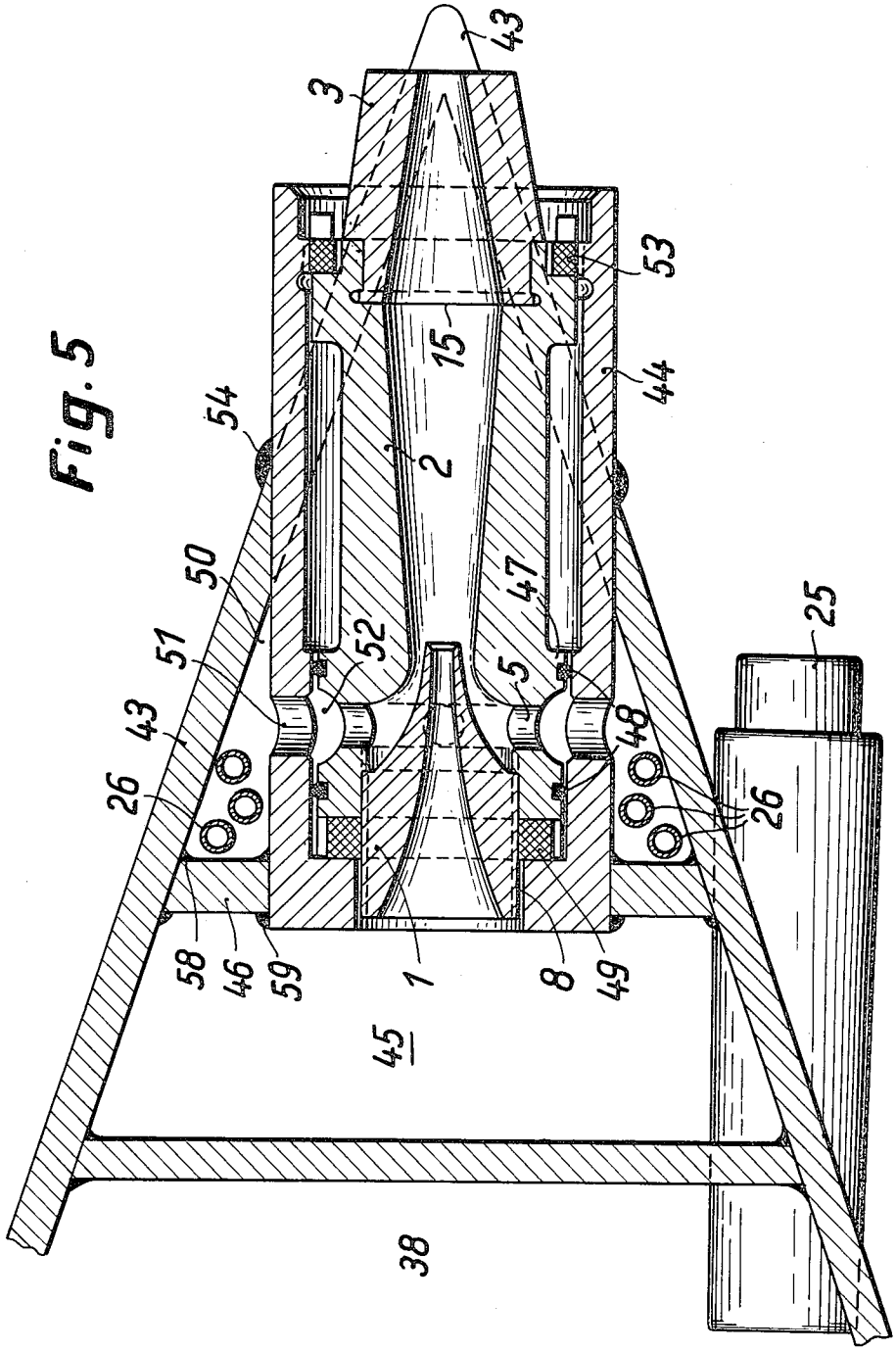
INVENTOR
Rudolf Hornstorf
BY
Braman & Braman
Attys

Fig. 4



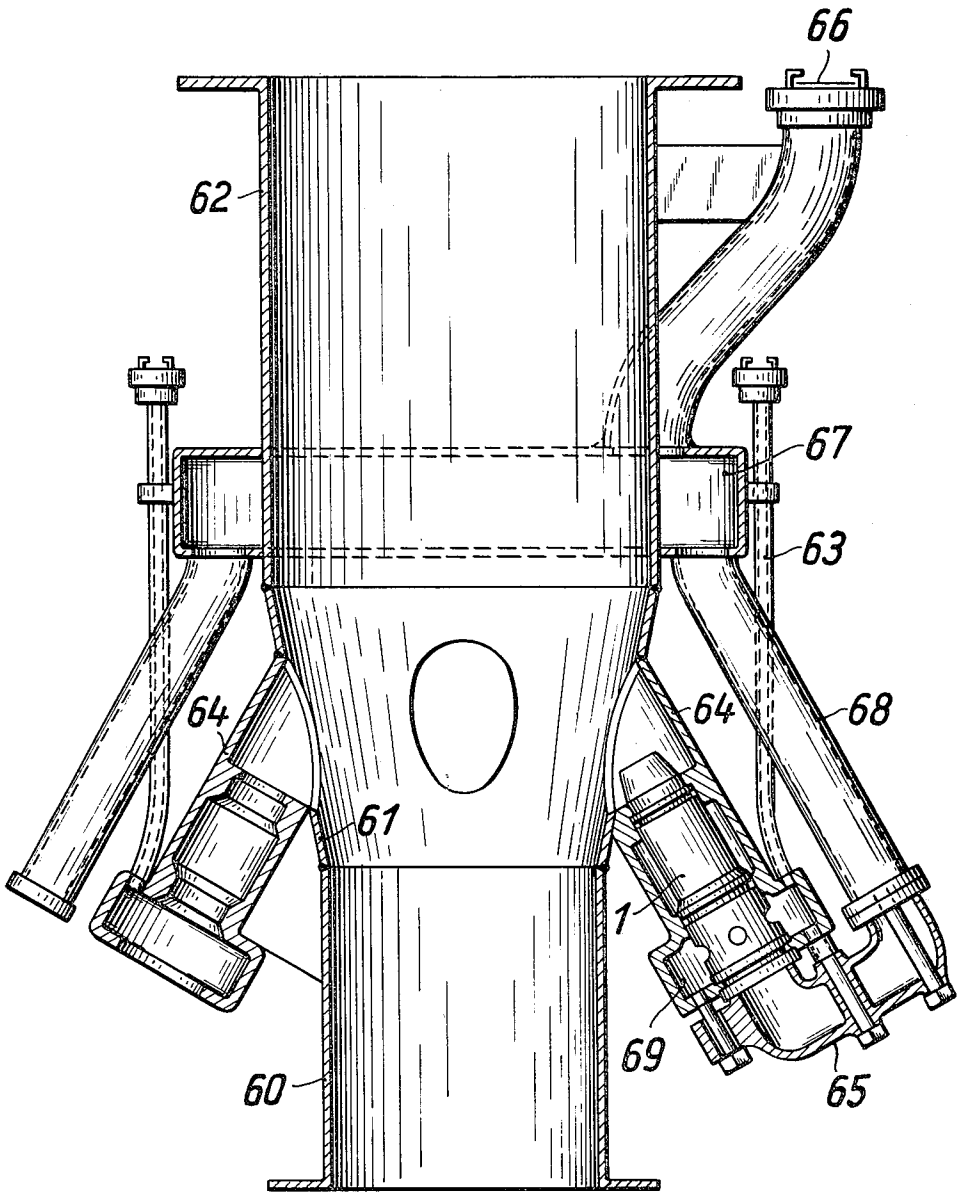
INVENTOR
Rudolf Hamstorf
BY
Brumm & Brumm
Attys

Fig. 5



INVENTOR
Rudolf Harmstorf
BY
Baman & Baman
attys

Fig.6



INVENTOR.
Rudolf Harmstorf
BY
Beaman & Beaman
Attys

METHOD OF AND APPARATUS FOR FLUSH-JET EMBEDDING STRUCTURAL ELEMENTS AND FOR SUCKING OFF GROUND MATERIAL

BACKGROUND OF THE INVENTION

The invention relates to a method of and an apparatus for flush-jet embedding structural elements, particularly pipes, into the ground, preferably into a water bed.

It is known to flush-bed structural elements with the aid of water jets. In this operation, a nozzle fed by pressure water is directed toward the ground. The jet accelerated in the nozzle loosens the soil, thus facilitating the movement of the structural element through the ground. Structural elements embedded by flush-jet bedding apparatuses can be cables, pipes and tubes, or corner-stakes. A pull is additionally exerted onto the flush-bedding apparatus, for instance, by means of a ship. Additional forces are exerted also onto the corner-stake to move it into the ground, usually by ramming or jar-ramming.

Although the invention is especially directed to the flush-jet embedding of structural elements into a water bed, it may be employed also for flush-jet embedding structural elements into the soil as well as for use with pressure water jet pumps which are also called ground suction apparatus. The invention relates accordingly to the breaking-up of the ground and flush-jet embedding of structural elements into the ground above or below the water level, as well as to the air-lifting of ground material.

The invention is concerned with the problem of improving the flushing effect of water jets, namely both with respect to breaking-up and holing of the ground as well as to flushing-away or transporting-off of the ground material which has been loosened by the flushing effect.

SUMMARY OF THE INVENTION

The problem is solved in accordance with the invention in that the fluid jet is formed of a mixture of water and air. Basically, this mixture may be formed by supplying to a pipeline on the one hand the pressure water and on the other hand the compressed air. It is a prerequisite for the troublefree operation of an apparatus forming this mixture, however, that both fluids be fed to the common line with exactly the same pressure. Even with small pressure differences the danger exists that the fluid with the higher pressure may be forced into the line of the other fluid.

In a preferred embodiment of the invention, a water jet is formed by conversion of pressure into speed which water jet draws in air by its jet action. This air may be taken directly from the atmosphere. It may be recommendable, however, to pressurize the air before mixing it with the water jet, which air pressure must be lower than the water pressure.

In a suitable manner, the mixture consisting of water and air is pressurized by reducing the velocity of flow before being directed against the ground in the form of a jet. In this way the mixture of water and air is improved and the jet action of loosening and breaking up the ground is increased.

After in this manner the fluid mixture has been pressurized, it is recommendable to accelerate the mixture anew so that it strikes upon the ground at an increased speed.

As already explained above, the object of the invention is especially to flush-bed structural elements into the ground of a waters. It has been found that a jet consisting of air and water when passing through the water to the ground to be loosened has substantially smaller losses of energy than a pure water jet so that with equal input energy the jet consisting of water and air exerts a greater force than a pressure water jet. Moreover, the erosion of the air-water jet on the ground material to be loosened is substantially greater than that of the pure water jet. Here is a phenomenon which may be compared with the effects of cavitation. The small air bubbles entrapped in the water with an overpressure after having left the nozzle expand directly adjacent the ground to be loosened. The bubbles lift the loosened ground material upwardly with them and induce an additional conveying operation. As the loosened ground material is transported off more quickly than with known methods, there results an increase in the erosion effect of the jet.

In an advantageous embodiment of the invention, the flowing mixture is subjected to pulsating pressure increases and decreases. This pulsation on the one hand, increases the erosion effect exerted on the ground and, on the other hand, generates an oscillation with small amplitude in the structural element which accelerates the working operation thus rendering it more economical.

The apparatus to put the process of the invention into practice is a jet pump forming the fluid mixture, the driving nozzle of said jet pump is fed by pressurized water.

The centrally arranged driving nozzle is enclosed by an annular chamber connected with the atmosphere. At least a part of this annular chamber is formed as a nozzle with a cross sectional area contracted in the direction of flow. The air is supplied through this nozzle to the water jet adjacent its smallest cross sectional area where its speed is highest.

In a preferred embodiment of the apparatus according to the invention this driving nozzle is joined to a diffuser in which the mixture consisting of water and air is pressurized by gradually decreasing its flow rate. This diffuser simultaneously serves to improve the mixture of air and water. It may be recommendable to include a mixing channel between the discharge opening of the driving nozzle and the beginning of the diffuser, with the cross-sectional area of said mixing channel being constant.

It is furthermore recommendable to join to the diffuser a nozzle section convergent in the flow direction in which the pressurized water and air mixture is accelerated to a speed at which the ground is loosened, eroded and lifted, while simultaneously reducing the pressure.

The air may be pressurized to a pressure prior to mixing it with the pressure water, said pressure, of course, being lower than the pressure of the water fed to the driving nozzle. If the air is pressurized, the pressure level of the nozzle operation is increased.

With a preferred embodiment of the invention, the nozzle aggregate constructed in accordance with the invention is detachably mounted at an apparatus adapted to be moved vertically through the ground for flush-jet embedding cables, pipes or hoses. In other embodiments of the invention the nozzle aggregate is

fastened to a corner-stake or mounted to a ground suction apparatus.

The nozzle aggregate used in the apparatus to carry out the method of the invention is a water-jet pump in which the ability not to draw off the air is essential to the jet action at the ground to be loosened, said jet consisting of a mixture of water and air.

BRIEF DESCRIPTION OF THE DRAWING

Further features and details of the invention are now being described by way of some embodiments of the apparatus according to the invention. In the drawings,

FIG. 1 shows a sectional view of a nozzle aggregate formed in accordance with a first embodiment of the invention,

FIG. 2 a sectional view of a second embodiment of the nozzle aggregate according to the invention,

FIG. 3 a view of a flush-bedding apparatus constructed in accordance with the invention for flush-jet embedding cables, pipes or hoses,

FIG. 4 shows a lower portion of a corner-stake in accordance with the invention which may be open or closed at the lower end thereof,

FIG. 5 shows a sectional view of the front portion of a flush-bedding apparatus constructed in accordance with the invention, said view being taken along the longitudinal center axis of one of the mixing nozzles 20, 21, 22, 28, 29, 32, for instance, of the mixing nozzle 20 shown in FIG. 3 and

FIG. 6 shows the nozzle aggregate according to the invention mounted in a ground suction apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with FIG. 1, the pressure water enters at 6 into a driving nozzle 1, the orifice 9 of which projects into a mixing nozzle 2 forming therein an annular space 11. The driving nozzle 1 is screwed into the pre-chamber 10 of the mixing nozzle 2 by means of a fine thread 8, whereby it is possible to regulate the driving nozzle 1 to an optimum output, for instance, on a test stand. The mixing nozzle 2 is formed as a conical divergent chamber 12 acting as a diffuser and having a thread 17 at its end 15 with an exit nozzle 3 screwed thereinto. The water entering into the driving nozzle 1 has been pressurized by means of a pump 70. The air enters into an annular chamber 4 via a conduit 7, said chamber 4 being connected by bores 5 with the pre-chamber 10 designed in the form of a nozzle. The air taken form the atmosphere is pressurized by means of a compressor 71. The air pressure, however, is relatively low and must be selected so that, for instance, the air in the pre-chamber 10 is under atmospheric pressure or is under pressure in excess of atmosphere pressure. The pressure of the water is essentially higher and is, for instance, 3 – 7 kg/cm^2, these statements, however, must not be understood as restrictions.

The pressure water entering into the driving nozzle 1 is accelerated by the shape of the nozzle. The water jet emerging from orifice 9 of the driving nozzle 1 generates a vacuum in the annular space 11 which is filled up via bores 5 by air introduced at 7 into the annular chamber 4 and being preferably pressurized. The conical divergent chamber 12 of the mixing nozzle 2 is a diffuser which causes a deceleration of the mixture jet and thus brings about a pressure increase. These speed and pressure variations lead to an improvement and a more uniform structure of the jet consisting of air and water.

After having passed the maximum diameter 15 of the diffuser 12 of the mixing nozzle 2, the mixture is accelerated in the nozzle chamber 16 of an exit nozzle 3, thereby reducing the pressure of the mixture. In this stage, the small air bubbles may be extended more or less in elongated air streams. When the mixture leaves the opening 18 of the exit nozzle 3, the jet forces into the ground for a short distance. The energy of the water and air of the mixture jet is here suddenly released and results in an intensive loosening of the soil material by the effect of the water and air combination, and a quicker transporting-off of the already loosened material.

The embodiment shown in FIG. 2 is essentially the same as that of FIG. 1. Both the diffuser chamber 12 and the exit chamber 16, however, are provided with alternate contractions 13 and expansions 14 so that a pulsating jet of a water/air mixture results. These pulsating jets on the one hand provide for an improvement of the erosive effect and on the other hand generate oscillations of the flush-bedding apparatus thereby additionally facilitating its desired movement through the ground.

FIG. 3 shows schematically a flush-jet bedding apparatus for flush-jet embedding a cable, a pipe or a hose. The flush-jet embedding apparatus 23 is pulled through the ground by means of a pulling device (not shown) which engages at the point 35 by means of a rope 34, for example. The flush-jet embedding apparatus 23 is provided with a duct 36 at the rear end to which the cable or the flexible pipe 19, respectively, is supplied from above. It leaves the apparatus at 37 at the rear lower end thereof.

The pressure water is supplied in a downward direction to two pressure water channels 38, 45 of the flush-jet embedding apparatus 23 via a connection piece 39 from a pump (not shown). Nozzles 25 are arranged along the sides of the flush-jet embedding apparatus front portion and possibly along the lower edge of the flush-jet embedding apparatus 23. Pressure water supplied via the passage 38 is discharged in the form of jets through the nozzles 25, said jets then loosening the ground material and flushing it away. In addition to the channel 38, further pressure water channels may be provided, in order to be able to subdivide the pressure water nozzles 25 into various groups which may be charged with pressure water at different rates.

The flush-jet embedding apparatus 23 is in addition provided with six mixing nozzles 20, 21, 22, 28, 29, 32 all of them constructed in accordance with FIGS. 1 and 2 and having pressure water supplied thereto via the channel 45. Compressed air is supplied to the mixing nozzles through separate lines 26 extending from the hose connection pieces 31 in the head member 30 through intermediate bottoms 27 arranged in air channel 33. Hoses adapted to feed compressed air to the mixing nozzles are connected to the connection pieces 31. The width of this flush-jet embedding apparatus is approximately governed by the diameter of the cable or pipe to be laid and is but little wider than said diameter.

FIG. 4 shows the lower portion of a corner-stake 55, the leftnhand side of which showing at 56 closed one and the right-hand side showing at 57 an open one, with mixing nozzles 40 fitted at the lower end thereof. The compressed air lines are indicated with 41, the pressure water lines with 42. These lines are guided upwards within the corner-stake 55 in a way not shown in more detail. Nozzles and lines constitute lost structural members in case it is not accessable, i.e., they will remain in the corner stake after the latter has been driven into the ground perhaps by additional ramming or jar-ramming.

FIG. 5 shows a sectional view of the front portion of a flush-jet embedding apparatus in accordance with FIG. 3 together with a mixing nozzle. The nozzle aggregate shown in this figure corresponds to that of FIG. 1, so that like reference numerals have been used for like parts. The wedge-shaped front portion of the flush-jet embedding apparatus is indicated by 43. A plurality of uniformly longitudinally distributed cylindrical sockets 44 are mounted therein by welding. The rear end of the driving nozzle 1 projects through the wall 46 of the front portion and into the water supply channel 45. The mixing nozzle 2 in this embodiment is provided with a grooved flange 47 which is sealed against the socket 44 by means of O-rings 48. The annular nut 49 locks the driving nozzle 1 in its optimum position which has been adjusted on the test stand.

The socket 44, the front portion 43 and the wall 46 are welded together at 54, 58, and 59. Compressed air is supplied to the chamber 50 formed in this manner through separate supply lines 26. (See also FIG. 3 with the intermediate bottoms 27). The compressed air may enter from chamber 50 into the annular chamber 52 via the bores 51 provided in the socket 44 which annular chamber 52 in turn communicates with the bores 5 of the mixing nozzle 2. The channel 45 is filled with pressure water, which now directly enters into the driving nozzle 1. The nozzle aggregate is inserted into the socket 44 from the front end; it is retained in its position by the annular nut 53 and may be relatively easily replaced, if necessary.

FIG. 6 shows a diagrammatic view of a known-per-se ground suction apparatus, which is provided with at least three of the above described mixing nozzles instead of conventional nozzles fed with pressure water only. A soil-and-water mixture is sucked in through the suction socket 60 by means of the reduced pressure generated by the jets. The mixture is conveyed through the conical tube portion 61 into the pressure socket 62. Three or more nozzle sockets 64 are fitted by welding in the conical portion 61, the bores of which are provided with guides and seats to support the nozzle aggregates. They are retained in their working position by the bend 65. Sealing against water and air is effected here as well by O-rings. The bend 65 simultaneously serves to supply pressure water to the nozzle. The water enters through a hose (not shown) at 66 and is introduced into the annular distributor chamber 67. The pressure water is supplied from chamber 67 to the nozzle aggregate via the pipe 68 and the bend 65.

The nozzle socket 64 is provided with an annular chamber 69 at the lower end thereof which is charged with compressed air via the pipe 63. This compressed air enters into the mixing chamber via the bores already described in connection with FIGS. 1 and 2 and is mixed with the pressure water charged thereinto. The water-air mixture blown into the conical tube portion 61 causes a substantial increase in the output of the suction apparatus. Heavy materials such as ores etc. may be lifted well by the air bubbles rising in the pressure socket 62 which may be elongated by further pipe joints.

What I claim is:

1. A method of flush-jetting a structural element such as a pipe or cable into the ground utilizing a jet formed of a combination of liquid and air comprising the steps of intermixing a jet of pressurized liquid with air under first pressure conditions, momentarily increasing the pressure of the flowing stream of intermixed liquid and air with respect to said first pressure to a second pressure to improve the intermixing of liquid and air, and accelerating the flowing stream and reducing the pressure thereof to a third pressure lower than said second pressure prior to impinging the mixture of liquid and air against the ground to be flush-jetted to loosen the ground and form a depression to receive the structural element.

2. A method of flush-jetting as in claim 1 including the step of rapidly changing the velocity and pressure of the flowing mixture of liquid and air prior to accelerating and reducing the pressure to said third pressure whereby pulses and vibrations are produced in the apparatus and resultant impinging jet stream.

3. Apparatus for laying a structural element such as a pipe or cable underground, particularly underwater, by flush-jetting a mixture of water and air comprising, in combination, embedding apparatus, a housing mounted on said embedding apparatus, an elongated mixing chamber defined in said housing having an inlet, an outlet, and an intermediate portion between said inlet and outlet, a nozzle mounted in said housing adjacent said inlet for introducing a jet of water into said chamber toward said outlet, a supply of pressurized water communicating with said nozzle, an air supply communicating with said chamber adjacent said inlet, said chamber intermediate portion including a plurality of axially spaced restrictions of varying cross-sectional dimension producing pressure pulses and vibrations in said housing, embedding apparatus, and in the jet ejected from said outlet.

4. Apparatus for laying a structural element such as a pipe or cable underground, particularly underwater, by flush-jetting a mixture of water and air comprising, in combination, embedding apparatus, a housing mounted on said embedding apparatus defining an elongated mixing chamber, a nozzle communicating with said mixing chamber adapted to jet a stream of water through said chamber, a pressurized water supply communicating with said nozzle, an air supply communicating with said mixing chamber intermixing air with said stream of water as water enters said mixing chamber, an outlet defined in said mixing chamber, said chamber being of increased diameter intermediate said nozzle and outlet whereby the pressure within the water stream momentarily increases prior to being reduced as the stream is ejected from said outlet into engagement with the ground to be loosened by flush-jetting, and at least one restriction defined in said chamber intermediate said nozzle and outlet producing a pulse in the jet stream ejected from said outlet and

producing vibrations in said housing and embedding apparatus.

* * * * *