March 3, 1970 MITSUO NISHIMURA ET AL 3,498,066

SOIL COMPACTING METHOD AND A MEANS THEREFOR

Filed March 8, 1968 6 Sheets-Sheet 1

FIG 1

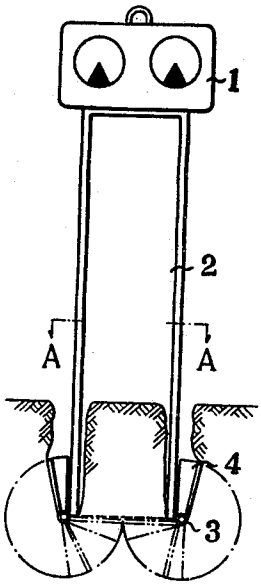


FIG 3

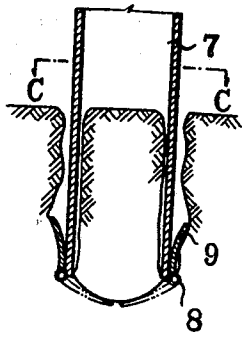


FIG 5

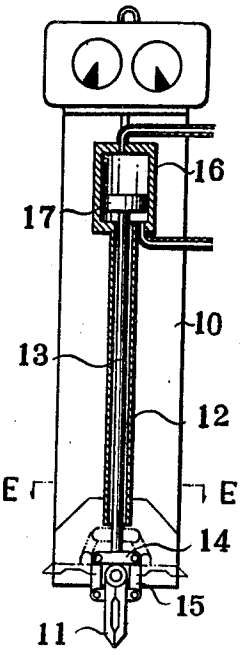


FIG 4

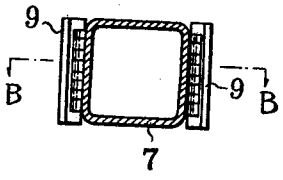


FIG 2

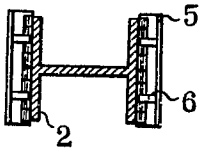


FIG 6

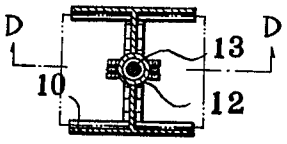


FIG 7

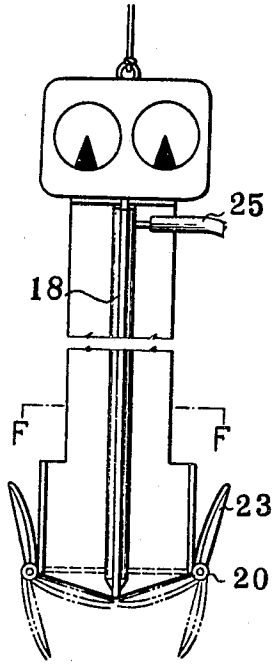


FIG 9

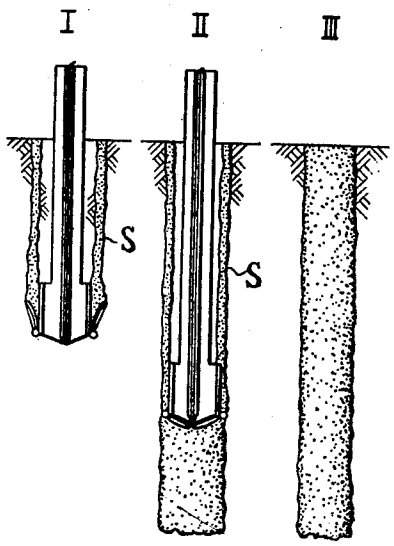


FIG 8

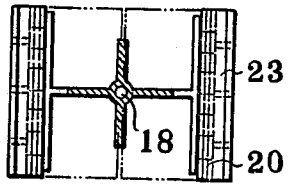


FIG 10

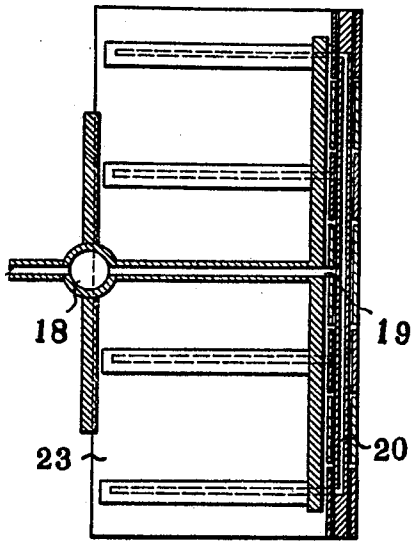


FIG 11

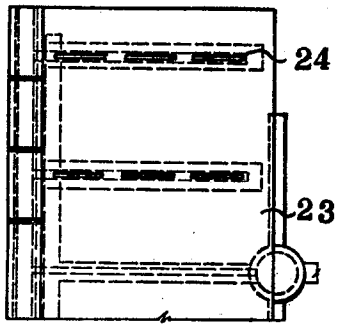


FIG 12

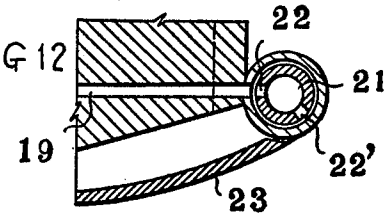


FIG 13

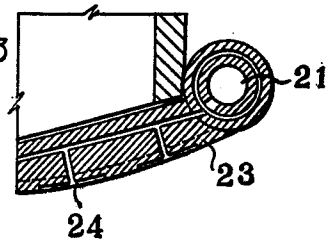


FIG 14

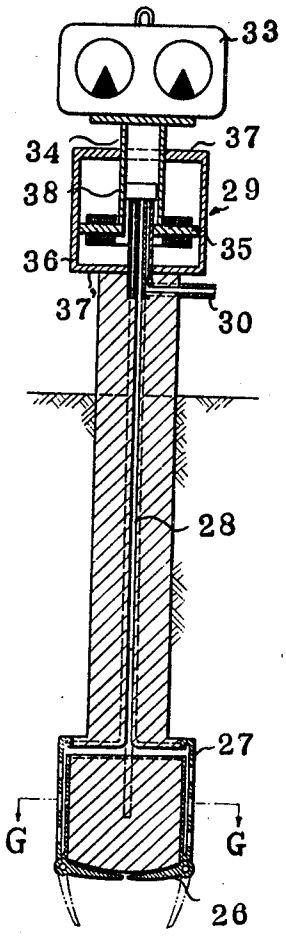


FIG 15

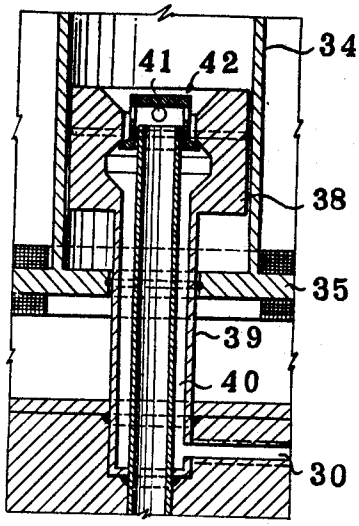


FIG 16

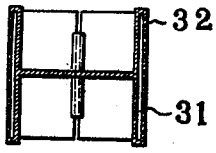


FIG 17

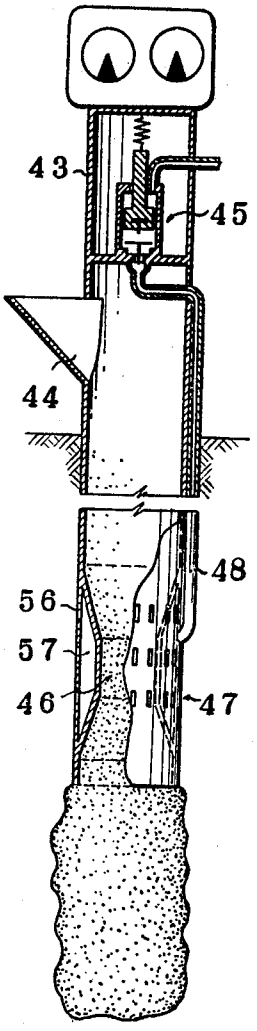


FIG 18

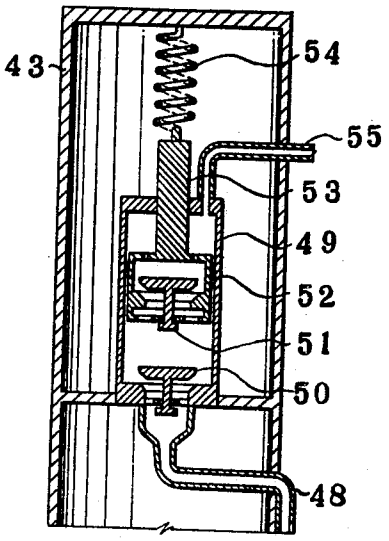
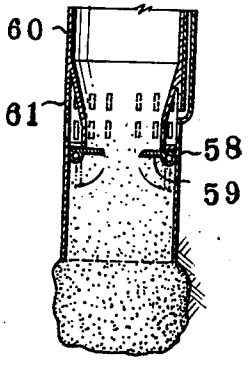


FIG 19



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FIG 20

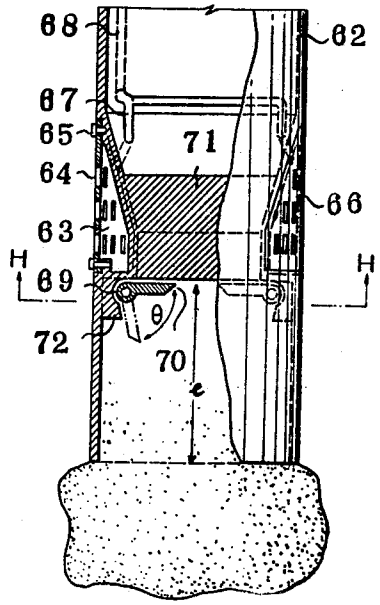


FIG 21

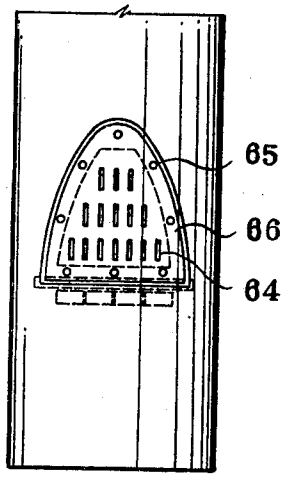


FIG 22

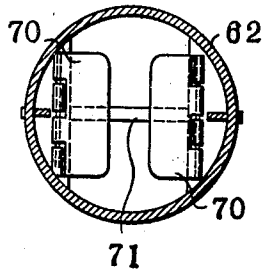
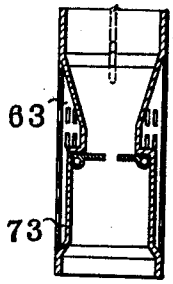


FIG 23



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3,498,066

SOIL COMPACTING METHOD AND A MEANS THEREFOR

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Claims priority, application Japan, Mar. 12, 1967, 42/15,495; Mar. 28, 1967, 42/19,307; Apr. 15, 1967, 42/24,171; Oct. 23, 1967, 42/68,152, 42/89,723
Int. Cl. E02d 5/38, 7/18, 3/10
U.S. Cl. 61—63 7 Claims

ABSTRACT OF THE DISCLOSURE

A soil compacting means comprising a pile provided with automatically swingable wings at the bottom thereof. While being vibrated, the pile is subsided down to a predetermined subsurface level so as to form a shaft, and then pulled up to the ground level while repeatedly elevated and subsided little by little, whereby the wall of the shaft is collapsed and the collapsed soil is transferred under the wings and compacted there together with the soil originally under the wings. The seepage water extraction and cement grouting are united with the compaction by particularly provided means built in the compacting means.

BACKGROUND OF THE INVENTION

Field of the invention

This invention belongs to the geotechnique or the method and means for improving the subsurface soil.

Description of the prior art

The mechanical method and means for compacting the subsurface soil have been substantially unknown. The loose sandy soil has been improved by adding sand, for example, by using the sand piles.

SUMMARY OF THE INVENTION

Briefly stated in accordance with one aspect of this invention, there is a soil compacting means comprising a pile and at least two wings. The method of compacting soil in accordance with this invention comprises steps of suspending the soil compacting means just on the ground level by a lifting means, downwardly displacing or subsiding the soil compacting means vertically with substantially vertically positioned wings by operating the lifting means so as to form a shaft having a cross section similar to that of the subsided soil compacting means, and pulling up the soil compacting means gradually while repeatedly subsiding and pulling up the same little by little by operating the lifting means, the wings being positioned automatically substantially horizontally during the last-named pulling up operations, whereby soil under the wings is compacted.

A vibrating unit is provided for applying vibration to the soil compacting means. The pile has a symmetrical cross section. The wings are hinged swingably to the bottom or near the bottom of the pile in a symmetrical manner with each other. The wings are positioned substantially vertically during the first subsiding operation and then automatically positioned substantially horizontally so that soil under the wings is compacted.

It is possible to unite cement grouting with the above method, whereby a cast-in-place concrete pile is easily constructed and installed. It is also possible to unite the seepage water extracting means with the soil compacting means, whereby difficulties due to the sandy soil having a poor water permeability are easily overcome.

The method in accordance with this invention does not require the addition of sand so that the method is inexpensive and not laborious. A compacted subsurface may be obtained promptly by virtue of the method and means in accordance with this invention.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood and other objects and additional advantages of the invention will become apparent upon perusal of the following description taken in connection with the drawings, in which:

FIG. 1 is a front elevational view of the first embodiment of this invention;

FIG. 2 is a cross-sectional view taken along line A—A in FIG. 1;

FIG. 3 is a partly removed vertically sectional view of the second embodiment of this invention taken along the line B—B in FIG. 4;

FIG. 4 is a cross-sectional view taken along line C—C in FIG. 3;

FIG. 5 is a vertically sectional view of the third embodiment of this invention taken along line D—D in FIG. 6;

FIG. 6 is a cross-sectional view taken along line E—E in FIG. 5;

FIG. 7 is a vertically sectional view of the fourth embodiment of this invention;

FIG. 8 is a cross-sectional view taken along line F—F in FIG. 7;

FIGS. I, II and III of 9 are explanatory views of operation for constructing and installing a cast-in-place concrete pile by the method in accordance with this invention using a soil compacting means shown in FIGS. 7 and 8;

FIG. 10 is an enlarged partly sectional fractional plan view of the wing of the fourth embodiment of this invention;

FIG. 11 is an enlarged fractional bottom view thereof;

FIGS. 12 and 13 are further enlarged vertically sectional views of a hinge for the wing shown in FIGS. 10 and 11, respectively;

FIG. 14 is a vertically sectional view of the fifth embodiment of this invention;

FIG. 15 is a vertically sectional view of the water exhausting means of the fifth embodiment similarly shown in FIG. 14 but enlarged;

FIG. 16 is a cross-sectional view taken along line G—G in FIG. 14;

FIG. 17 is a vertically sectional view of the sixth embodiment of this invention;

FIG. 18 is a vertically sectional view of the water exhausting means of the sixth embodiment similarly shown in FIG. 17 but enlarged;

FIG. 19 is a partly removed vertically sectional view of the water extracting means and wings of the seventh embodiment of this invention;

FIG. 20 is an enlarged fragmentary vertically sectional view of the water extracting means and wings of the eighth embodiment of this invention;

FIG. 21 is an enlarged side elevational view corresponding to FIG. 20;

FIG. 22 is an enlarged cross-sectional view taken along line H—H in FIG. 20; and

FIG. 23 is a vertically sectional fragmentary view of the water extracting means of a modification of the eighth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawings, the preferred embodiments of this invention will now be de-

scribed; however, this description will be understood to be illustrative of the invention and not as limiting it to the particular methods and constructions shown and described. Referring now specifically to FIGS. 1 and 2, reference numeral **2** designates a pile having a H-section. A vibrating unit **1** is fixed on and to the top of the pile **2**. The vibrating unit **1** is hung from a suitable lifting means (not shown) and is capable upon activating the lifting means to generating a vertical vibration. A wing **4** is hinged to the bottom edge of each side plate of the pile **2** by means of a hinge **3** in such a manner that each wing **4** is in close contact with the outer surface of the side plate during the pile **2** is being subsided as shown in FIG. 1, while it may be hung from the bottom of the pile **2** when the pile is pulled upwards.

Each wing **4** is formed by a plate **5** reinforced by at least two ribs **6** protruded therefrom, and arranged vertically and tapered towards the hinge **3**. The space between the two ribs **6** are left open at the free ends of the wing **4** so that the subsiding operation of the pile **2** is not substantially obstructed by the wings **4** and the space between the two ribs **6** is left vacant during the first subsidence. When the pile **2** is pulled up by the lifting means, the space between the two ribs **6** is naturally filled up with soil separated from the internal wall of the shaft formed by the subsiding operation.

In operation, the pile **2** hung from the lifting means is lowered down to the ground level by operating the lifting means. The virbrating means **1** is actuated and slackened slightly from the lifting means so that the pile **2** begins the subsiding action into the soil in the conventional manner, while the wings **4** are positioned upwards. After the pile **2** has been subsided down to a predetermined subsurface level, the lifting means is actuated so as to pull up the pile **2** along a short lift, while being vibrated continuously. The space between the two ribs **6** of the wing **4** has been filled up with soil separated from the internal wall of the shaft formed by the first subsiding operation and then the wings **4** are naturally turned down while the pile **2** is thus pulled up. When the wings **4** are turned down, a vacant space is formed behind the wings **4** which is immediately filled up with soil separated from the ceiling of the space by virtue of its own weight and the vibration.

Then the lifting means is slackened again and the pile **2** is lowered again. However, the wings **4** do not completely turn upwards because the space on the plates **5** of the wings **4** has been filled up with soil, so that the soil under the wings **4** is forcedly compacted while the pile is again lowered. The pulling up and lowering operations are repeated while the pile **2** is pulled up to the original position on the ground level gradually. At the same time, the shaft once formed by the pile **2** becomes shallower and shallower by being filled with the denser soil displaced from the surroundings and forcedly compacted by the wings **4** so that the bearing capacity of the ground is improved.

FIGS. 3 and 4 show the second embodiment of the invention, of which the pile **7** comprises a pipe having a square section instead of the H-section. Two sides of the pile **7** opposite with each other is provided with the wings **9** hinged to the bottom edge thereof on pins **8**. The wing **9** is not formed with the ribs but has a crescent radial section in such a manner that the free end of the wing **9** is separated from the outer surface of the pile **2** when the wing **9** is positioned upwards. By virtue of the shape of the wings **9**, it is turned downwards about the pin **8** when the pile **7** is pulled up. The soil compacting means of the second embodiment shown in FIGS. 3 and 4 may be operated in the quite similar manner with the preceding embodiment.

FIGS. 5 and 6 show the third embodiment of the invention, of which the pile **10** has a H-section. The two side plates or flanges of the H-sectional pile **10** is extended downwards somewhat longer than the web. A web is formed with a cylinder **16** and a guiding pipe **12** arranged concentrically with the pile **10**. The cylinder **16** is arranged near the top end of the pile **10** and provided with a top passage and a bottom passage for passing a liquid into and out of the cylinder **16**. A piston **17** is adopted to be reciprocated vertically inside the cylinder **16** and provided with a connecting rod **13** extended downwards inside the guiding pipe **12** adapted to surround the connecting rod **13** in close contact therewith for transmitting the reciprocation of the piston **17** to the bottom end of the connecting rod **13**. The lowermost end of the connecting rod **13** extended beyond the lowermost end of the guiding pipe **12** is provided with a lateral branch **14** and integrated therewith as a T.

There is a shaft just below the web of the pile **10** and below and across the branch **14** of the connecting rod **13**, extending laterally between the two flanges of the pile **10**. A pair of wings **11** are swingably mounted on the shaft and linked with the extremities of the lateral branch **14** of the connecting rod **13** by means of connecting arms **15**, respectively. By the above construction, the wings **11** may be operated by the piston **17** which may be operated by actuating the lifting means intermittently and moving and the outlet of the cylinder **16**.

In operation, the pile **10** is subsided in the similar manner to the preceding embodiment, while the piston **17** is kept in the lowermost position so as to keep the two wings **11** in the vertical position in close contact with each other. After the pile **10** has been subsided down to a predetermined subsurface level, the pile **10** is elevated along a short lift and then the piston **17** is elevated up to the uppermost position in the cylinder **16** by the pressured liquid admitted thereinto through the bottom passage therefor, so that the two wings **11** are swung outwardly apart from each other. When the wings **11** are spread as above, the space on the wings **11** is not vacant. However, the soil occupying the space has not been compacted so that it is easily possible to spread the wings **11**. Then the pile **10** is again subsided with the spread wings **11** so that the soil under the wings **11** is compacted. The elevation of the pile **10** with the closed wings **11** and the subsidence of the pile **10** with the spread wings **11** are alternately repeated, while the pile **10** is elevated gradually, by actuating the lifting means intermittently and moving the piston **17** in the alternate direction correspondly thereto. When the pile **10** has been pulled up to the ground level, there has been formed a shaft having a compacted bottom including the surrounding space also. It is to be noted that the vibrating unit is activated during the operation as in the preceding embodiments.

In the fourth embodiment of FIGS. 7 to 13, inclusive, a pile having a cruciform cross section and a centrally axial integrated pipe **18** is used. The lowermost parts of the two opposite flanges of the four flanges of the pile are somewhat laterally extended and the vertical extremities of the extended flanges are further flanged vertically at the right angle thereto, respectively, so as to form two side plates in the similar form to those in the first and second embodiments. Two wings **23** are hinged by the bottom edges of the two side plates, respectively. The appearance of these wings **23** and the mounting thereof is substantially similar to that in the second embodiment but the function is extended by the following construction.

The axial pipe **18** integrated in the pile is provided with a sidewise inlet **25** near the top thereof and two branches **19** near the bottom thereof. The branched pipe **19** is integrated with the flange of the pile which is provided with the side plate at the outer end thereof, and opened at the lowermost extremity of the side plate where a shaft integated with the wings **23** is journalled swingably by the side plate. The shaft is formed into a pipe **20** having two radial leading holes **22** and **22'**. One leading hole **22** is adapted to be communicated with the branched pipe **19** when the wing **23** is in the closed position where the two

wings 23 have been turned towards each other as shown in II of FIG. 9 and FIG. 12, so that the pipe 20 is communicated with the branched pipe 19. The other leading hole 22' is adapted to be communicated with the branched pipe 19 when the wing 23 is in the opened position where the two wings 23 have been turned away from each other as shown in FIG. 7 and I of FIG. 9, so that the pipe 20 is also communicated with the branched pipe 19. Thin pipes 24 are provided in the wings 23 to extend the pipe 20 throughout the wings 23 and to a number of parts of the outwardly inflated surfaces thereof which are positioned downwards in the closed position of the wings 23.

The fourth embodiment of this invention may be operated for two different functions. In one mode of the operations, a cast-in-situ concrete pile is formed. During the period that the pile is subsided at first in the similar manner as in the preceding embodiments, cement milk is charged through the inlet 25 under pressure by a suitable conventional means (not shown). In this stage of the operation, the wings 23 are kept naturally in the opened position or turned upwards outside the side plates as shown in FIG. 7 and I of FIG. 9. The charged cement milk is forcedly passed through the pipe 18, branched pipes 19, leading holes 22', pipes 20 and thin pipes 24 to the outer surfaces of the wings 23, which face the side plates of the pile at this stage, whence the cement milk is grouted from the wings 23 into the wall of the shaft being formed. When the pile is pulled up along a short lift similarly to the preceding embodiment after the pile has been subsided to a predetermined subsurface level, the wings 23 are suspended downwards from the side plates. Since the wings 23 are situated as above, the communication from the branched pipes 19 to the pipes 20 is interrupted so that the cement milk is not injected. When the pile is again lowered, the two wings 23 are turned into the closed position under the pile by virtue of the outwardly inflated shape thereof. In this situation the communication from the branched pipe 19 to the pipe 20 is again kept conductive through the leading hole 22, so that the cement milk is grouted downwards from the downward surfaces of the wings 23 as shown in II of FIG. 9 and FIGS. 12 and 13. Thus the soil under the wings 23 is compacted and, at the same time, grouted with the cement milk in accordance with the repetition of the vertical motion of the pile so as to form a soil cement pile which groups upwards correspondingly to the gradual pulling out of the pile, as shown in II and III of FIG. 9.

In another aspect of operations of the fourth embodiment of this invention, the soil compacting means in accordance with the fourth embodiment is particularly adapted to handle a soil having the least water permeability. The soil compacting operation encounters difficulties in treatment of such poorly water permeable soil because of the seepage pressure elevated by virtue of the difficulties in oozing of intergranular or void water in such soil in the process of the compacting operation therefor. In such a case, the inlet 25 is used as an outlet connected with a vacuum means. The intergranular or void water oozed out of the soil being compacted is extracted through the thin pipes 24, whence the water is passed through the pipes 20, leading holes 22, branched pipes 19 and the pipe 18 to the inlet 25 so as to be removed out of the soil compacting means. By virtue of this operation, it is possible to compact such poorly permeable soil. For cleaning the piping system in the soil compacting means in accordance with the fourth embodiment, it is preferred to provide a draining means at the lowermost end of the pipe 18.

The fifth embodiment of this invention is shown in FIGS. 14, 15 and 16, in which a water exhausting means 29 and a water extracting means 27 are provided in order to treat highly water-bearing soil. The water exhausting means 29 is arranged under the vibrating unit and on the top of pile having a cruciform cross section and a centrally axial integrated pipe 28 similarly to the pipe of the fourth embodiment. The water extracting means 27 is arranged under the pile. Two opposite flanges of the pile are more extended downwards than the other two opposite flanges and further flanged into vertical side plates similarly to the corresponding member of the fourth embodiment, respectively, so that the bottom part of the pile has a H-section as shown in FIG. 16. Two wings 26 are hinged to the lowermost edges of the side plates, respectively, as shown in FIG. 14. The side plate comprises a thin box 31, of which the outer plate is provided with a number of strainers 32. The interior of the thin box 31 is communicated with the axial pipe 28 of the pile. Thus the water extracting means 27 comprises the two thin boxes 31 and the axial pipe 28 with the communicating pipes therebetween.

The water exhausting means 29 is a kind of pump and completely automatically exhausts the water in the pipe 28 out of this soil compacting means, being driven by the vibrating unit 33. There is an outer cylinder 36 having a top disc 37 to be pressured during the pile is being pulled up and a bottom disc 37' to be pressured during the pile is being lowered. The bottom disc 37' is secured to the top edges of the flanges of the pile concentrically. An inner cylinder 34 is adapted to be vertically slidable in a central hole formed through the top disc 37 and secured to the bottom of the vibrating unit 33 at the top edge thereof. The inner cylinder 34 extended inside the outer cylinder 36 has a driving disc 35 at the bottom thereof which is extended radially as a flange to the close proximity of the inside wall of the outer cylinder 36 so as to form a piston for the latter. The inner cylinder 34 is provided with a piston 38 adapted to be vertically slidable therein. The bottom surface of the piston 38 is downward concentrically extended into a sleeve 39, which slidably passes through a central hole formed in the driving disc 35 and also fixedly passes through a central hole formed in the bottom disc 37'. The bottom part of the sleeve 39 is fit in the top notches of the four flanges of the pile, secured thereto and provided with a bottom disc. The top of the pipe 28 is extended upwards, fixedly passes through the bottom disc of the sleeve 39 and inserted into the sleeve 39 and the piston 38 so as to form an annular passage between the inner wall of the sleeve 39 and the outer wall of the pipe 28. There is a double acting check valve 42 at the top end of the pipe 28 inside the piston 38. The double acting check valve 42 communicates the pipe 28 with the space on the piston 38 through a passage 41 formed in the piston 38 and, at the same time, closes the annular passage at the top thereof during the inner cylinder 34 is being elevated, as shown in FIG. 15. During the inner cylinder 34 is being lowered, the double acting check valve 42 communicates the space above the piston 38 with the annular passage and the pipe 28 is closed at the top thereof. The annular passage is extended out of this soil compacting means by a sidewise pipe 30 for exhausting water.

In operation, at first the pile with the outward turned wings 26 is subsided similarly to the preceding embodiment. After the pile has been lowered down to a predetermined subsurface level, the alternation of the pulling up and lowering of the pile is repeated also in the similar manner to the preceding embodiment. The bottom end of the pile is closed by the wings 26 and the seepage water is extracted through the strainers 32 into the thin boxes 31 in the following manner.

During the inner cylinder 34 is being elevated, the double acting check valve 42 takes the upper position as shown in FIG. 15 so that the pressure of the space upon the piston 38 and the pipe 28 communicated therewith through the passage 41 is reduced. By virtue of this reduction in pressure, the seepage water is extracted through the strainers 32, thin box 31, axial pipe 28 and the passage 41 into the space upon the piston 38. During this period, the communication of the space upon the piston 38 with the annular passage between the sleeve

39 and the pipe 28 is interrupted by the double acting check valve 42. When the inner cylinder 34 begins to be lowered, the double acting check valve 42 is lowered by the action of the water accumulated in the space upon the piston 38 and pressured by the lowering inner cylinder 34, so that the communication of the space upon the piston 38 with the pipe 28 is checked and, at the same time, the space is communicated with the annular passage between the sleeve 39 and the pipe 28, whence the accumulated water is expelled out of this soil compacting means through the sidewise pipe 30. Thus by removing the seepage water the soil is made more compact.

FIGS. 17 and 18 show the sixth embodiment of this invention, in which a tubular pile 43 is used. A vibrating unit on the top end of the tubular pile 43 and a hopper 44 is provided, the latter being formed on a side of the tubular pile 43 near the top thereof. In operation, sand is charged into the tubular pile 43 through the hopper 44 while being vibrated by the vibrating unit. The tubular pile 43 has an annular double walled part near the open bottom end thereof, which comprises a vertically straight outer wall 56 and an internally inflated inner wall so as to form a neck 46 of the tubular pile 43 which is required for pushing down the sand supplied from the hopper 44. A water extracting means 47 is formed by the annular double walled part, of which the outer wall 56 is provided with a number of strainers so as to open the space between the outer wall 56 and the inner wall externally.

There is provided a resonance water exhausting means 45 within the tubular pile 43 between the top end thereof and the hopper 44. The resonance water exhausting means 45 comprises a cylinder 49 and a piston 52. The cylinder 49 is arranged vertically and secured to the tubular pile 43. A first check valve 50 is provided on an inlet of the cylinder 49 arranged through the bottom wall thereof, whence a riser pipe 48 is extended down to the water extracting means 47. The piston 52 is adapted to reciprocate vertically in the cylinder 49, of which a piston rod 53 is extended upwards through a hole formed in the top wall of the cylinder 49. The top end of the piston rod 53 is connected with the top wall of the tubular pile 43 by a coil spring 54 so as to hang the piston 52 from the top wall and to transmit the vibration of the vibrating unit to the piston 52. It is to be noted that it is necessary that the piston rod 53 is relatively heavy. The piston 52 is provided with an inside cavity having several smaller openings at the top thereof and a larger opening at the bottom thereof. The bottom opening is provided with a second check valve 51 so as to pass water in the single upward direction. A water exhausing pipe 55 is extended externally across the wall of the tubular pile 43 from the top of the cavity.

The piston 52 is vertically reciprocally vibrated in resonance with the vibration generated by the vibrating unit and the subsiding and pulling up operations of the tubular pile 43, resulting in that the seepage water is extracted from the surrounding soil into the water extracting means 47, whence conveyed to the cylinder 49 through the riser pipe 48 and exhausted out of the soil compacting means through the two check valves 50 and 51 and the water exhausting pipe 55. It is preferred that smaller vibrations of the tubular pile 43 are absorbed by the coil spring 54 and only larger vibrations are transmitted to the piston rod 53. In general, the phase of the vibration becomes opposite by the transmission.

FIG. 19 shows the seventh embodiment of this invention, which is a modification of the sixth embodiment. The soil compacting means in accordance with the seventh embodiment is provided with a pair of swingable wings 59. The wing 59 is hinged inside the wall of the tubular pile 60 quite similar to that of the preceding embodiment just below the water extracting means 61 and functions similarly to that of the fifth embodiment.

FIGS. 20, 21 and 22 show the eighth embodiment of this invention, which also comprises a tubular pile 62. A vibrating unit (not shown) is provided on the top end of the tubular pile 62 and a water extracting means is provided near the bottom end thereof. A water exhausting means is not integrated with the tubular pile 62, but a conventional drainage pump (not shown) is utilized.

The water extracting means comprises a pair of water extracting semi-elliptic compartment 63, of which the bottom end is arranged horizontally and corresponds to the minor axis of the ellipse. Each of the semi-elliptic compartments 63 arranged opposite to each other is formed by an internally inflated part of the wall of the tubular pile 62 and covered by a strainer 66 having the same curvature with the tubular pile 62. The strainer 66 is provided with a number of perforations 64 and detachably fixed on the tubular pile 62 by means of several screws 65 so that it is facilitated to clean the water extracting compartments and remove sand out thereof. The interior of the water extracting compartment is communicated with a conventional drainage pump (not shown) placed on the ground level by means of a riser 68 and the branches 67 thereof, so as to exhaust water extracted into the water extracting compartments out of this soil compacting means.

There are a pair of hinges 69 just under the lower end of the internally inflated walls, on which a pair of wings 70 are carried in the similar manner to those of the seventh embodiment, for the soil compacting operation. A central vertical partition 71 is provided between the two internally inflated parts of the wall of the tubular pile 62 and fixed thereto for reinforcing the two compartments 63. In addition, the lowermost edge of the partition 71 serves to limit the upward swinging of the wings 70 to the horizontal situation thereof. The downward and outward swinging of the wings 70 is limited by a pair of ribs 72 integrated with the wall of tubular pile 62 to a slightly inward situation of the wings 70, so that the swinging stroke θ is slightly smaller than the right angle, as shown in FIG. 20. A vertical distance e from the wings 70 at the horizontal situation to the lowermost edge of the tubular pile 62 is determined by the feeding operation of the additional sand. In general, it is preferred to select the length of 30 to 60 cm. for the distance e.

In operation, the soil compacting means in accordance with the eighth embodiment is subsided down to a predetermined subsurface level, while being vibrated by the vibrating unit (not shown). At the same time, the interior of the tubular pile 62 is charged with sand from a hopper (not shown). The wings 70 are swung upwards by the subsurface sand. By virtue of the upward limit of the swinging motion rendered by the central vertical partition 71, the wings 70 is kept in the horizontal position so as to compact the soil thereunder. After the tubular pile 62 has arrived at the subsurface, it is pulled up gradually while repeating the little by little elevating and lowering, and a sand pile is thus formed by feeding the additional sand into the tubular pile 62 under pressure. During this period the seepage water is extracted through the strainers 66 forcibly into the water extracting compartments 63 whence exhausted out of the soil compacting means through the branches 67 and the riser 68 by means of the drainage pump. In a midification of this embodiment shown in FIG. 23, the water extracting compartments 63 are extended downwards so as to extract the seepage water more effectively.

While particular embodiments of the invention have been illustrated and described, modifications thereof will readily occur to those skilled in the art. It should be understood therefore that the invention is not limited to the particular arrangements and methods disclosed but that the appended claims are intended to cover all modi-

fications which do not depart from the true spirit of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A soil compacting means comprising a pile having a symmetrical cross-section, a vibrating unit mounted on the top of said pile, and at least two wings pivotally horizontally to the bottom of said pile by tubular hinges in a symmetrical manner with each other so as to flap automatically between a vertical position and a horizontal position said pile being provided with a pipe in communication with said hinges and said wings are hinged and provided with a number of thin pipes having opened ends, through which a liquid flows.

2. A soil compacting means as claimed in claim 1, wherein said wings are positively driven.

3. A soil compacting means as claimed in claim 1, wherein a water exhausting means is provided and driven automatically by impact given by progressive and successive subsiding and pulling up operations of said soil compacting means, whereby seepage water is extracted into the bottom of a pipe in said pile and exhausted out of the top of said pipe.

4. A soil compacting means as claimed in claim 1, wherein at least two water extracting chambers are provided symmetrically at the lower end of said pile, said pile being structured into the form of a tube, and said chamber having a number of strainers for extracting seepage water into said chamber.

5. A soil compacting means as claimed in claim 1, wherein a grouting means is provided for communicating from the ground level to the surface of said wings.

6. A soil compacting means as claimed in claim 1, wherein a seepage water extracting means communicating from the ground level to the surface of said wings is provided for extracting seepage water by vacuum.

7. A soil compacting means as claimed in claim 3, wherein a seepage water extracting means connected with a water exhausting means is provided.

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