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Frederick

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[54] **JET SHEET AND CIRCULAR PILE WITH WATER HAMMER ASSIST**

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[52] **U.S. Cl.**..... **61/53,** 61/53.5, 61/53.74, 61/58, 61/60

[51] **Int. Cl.**..... **E02d 5/00,** E02d 5/04

[58] **Field of Search** 61/53.74, 53.5, 53, 58, 61/59, 60, 61, 62

[56] **References Cited**

UNITED STATES PATENTS

927,963	7/1909	Gibb	61/60
1,529,112	3/1925	Burns	61/53.74
2,128,740	8/1938	Dougherty	61/60

FOREIGN PATENTS OR APPLICATIONS

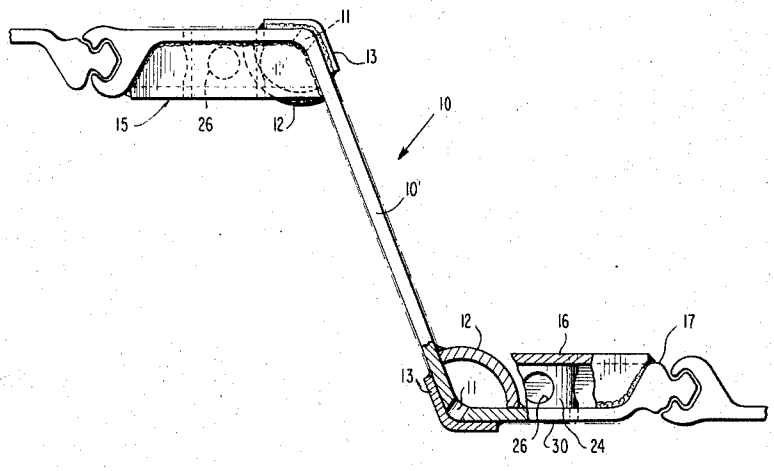
255,059	3/1964	Netherlands	61/58
163,121	9/1905	Germany	61/53.74

Primary Examiner—Jacob Shapiro
Attorney, Agent, or Firm—Edwin E. Greigg

[57] **ABSTRACT**

The invention relates to a system of furnishing a supply of lubricant to the opposed sides of a section of piling and a movable drive shoe carried thereby to facilitate the driving of the piling in any type of earthen strata.

15 Claims, 11 Drawing Figures



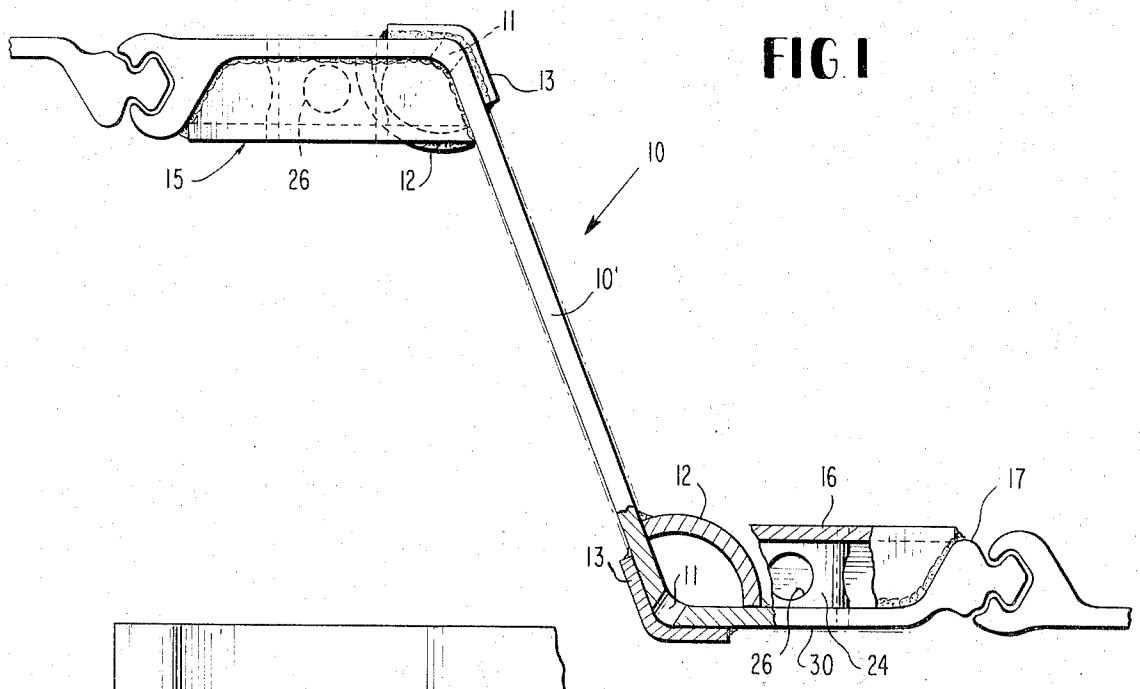

11
13
15
26
12
10
10'
12
16
17
13
11
26
30
24

FIG. 1

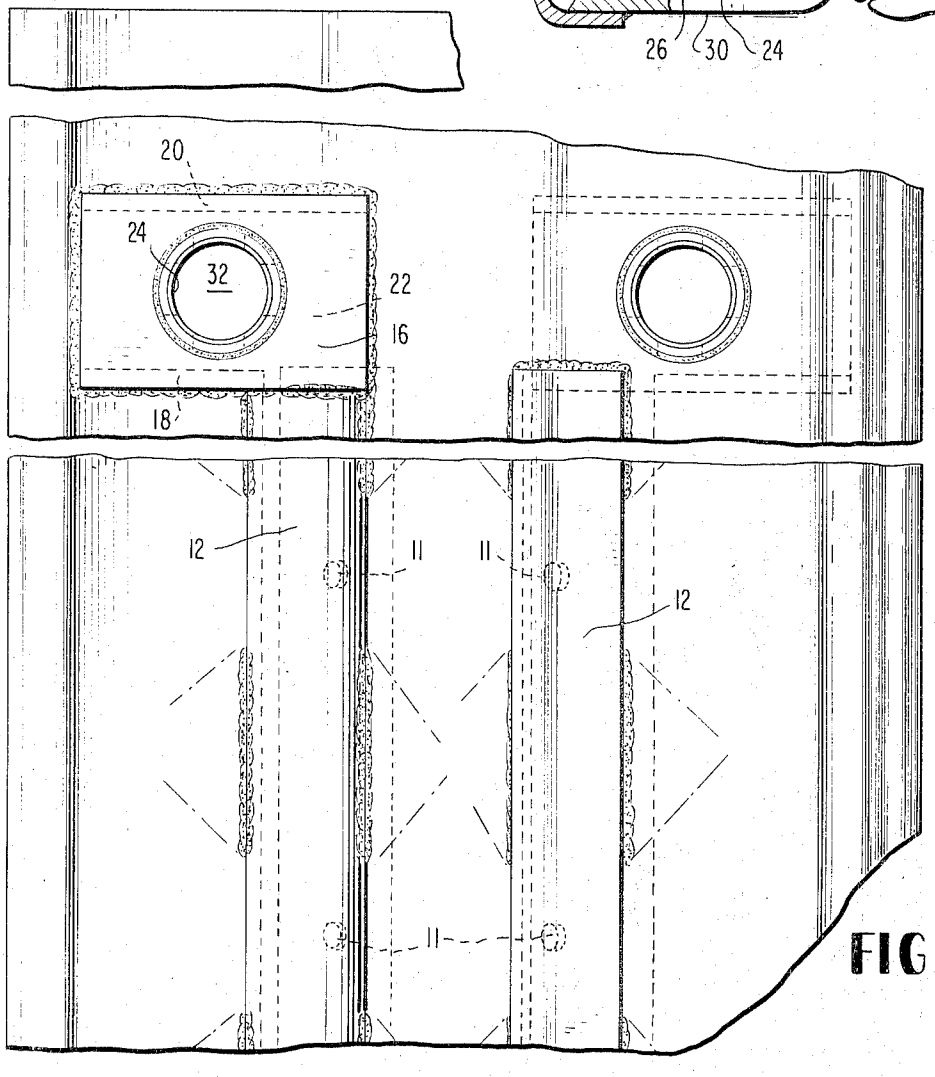

20
24
32
22
16
18
12
11
11
12
11

FIG. 2

FIG. 3

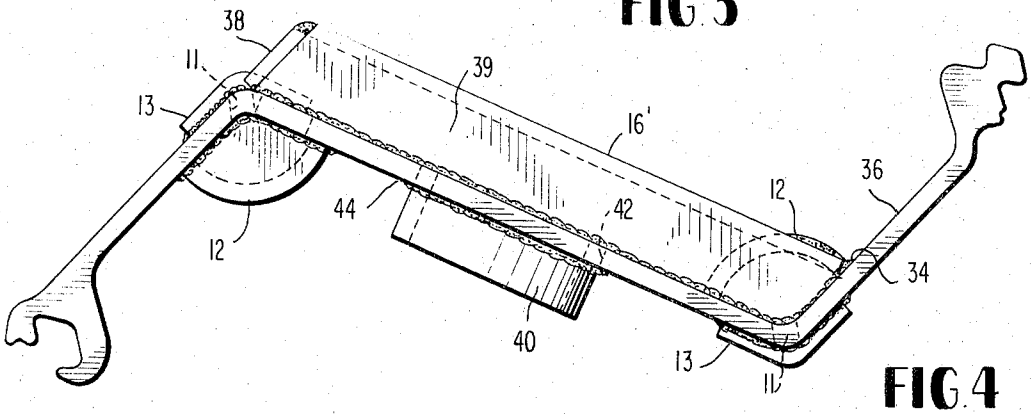
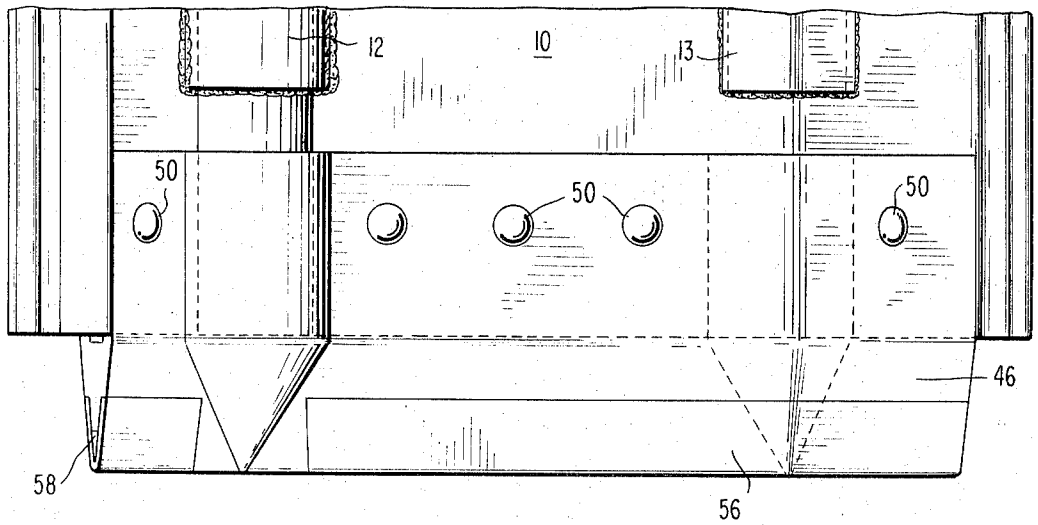


FIG. 4



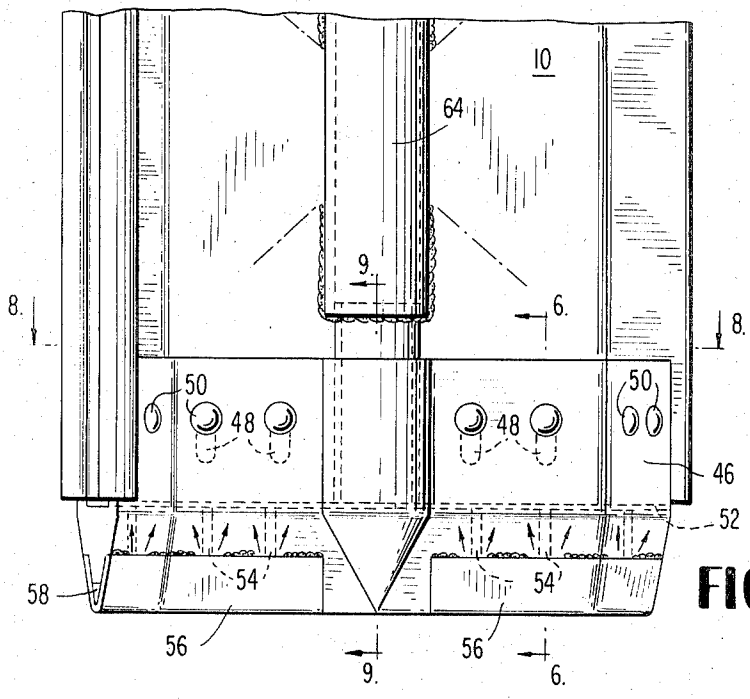


FIG. 5

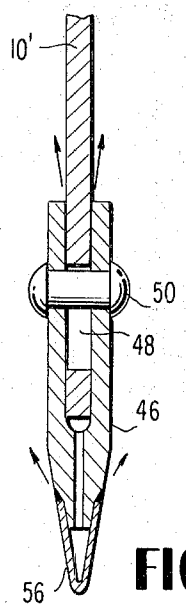
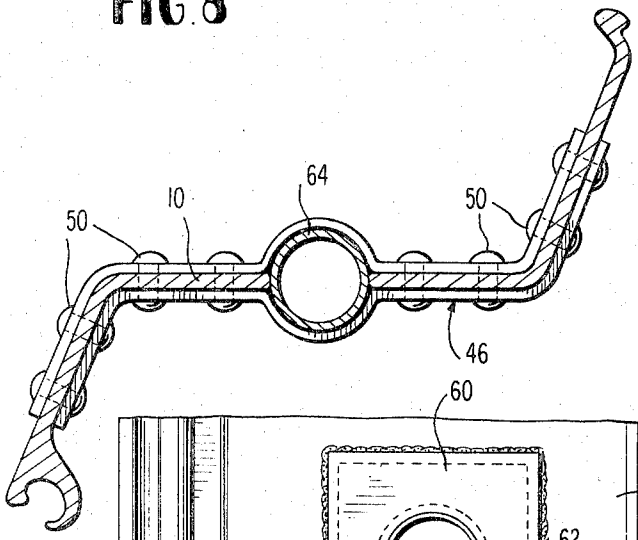


FIG. 6

FIG. 8



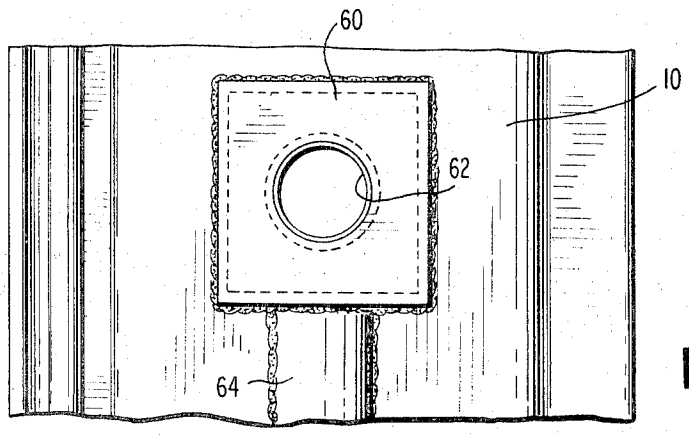


FIG. 7

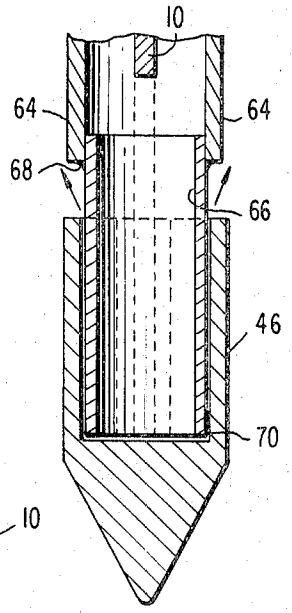


FIG. 9

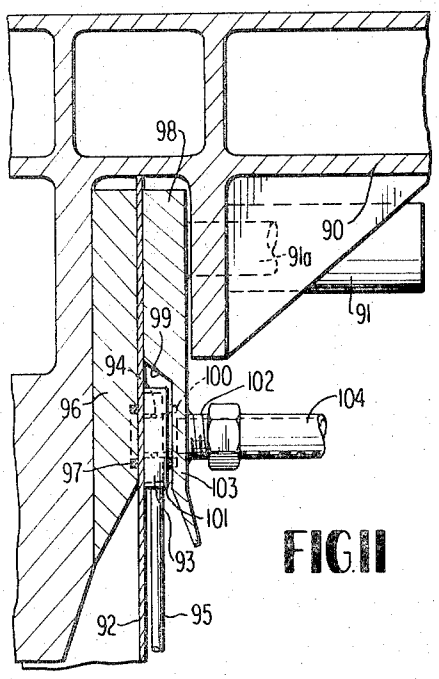
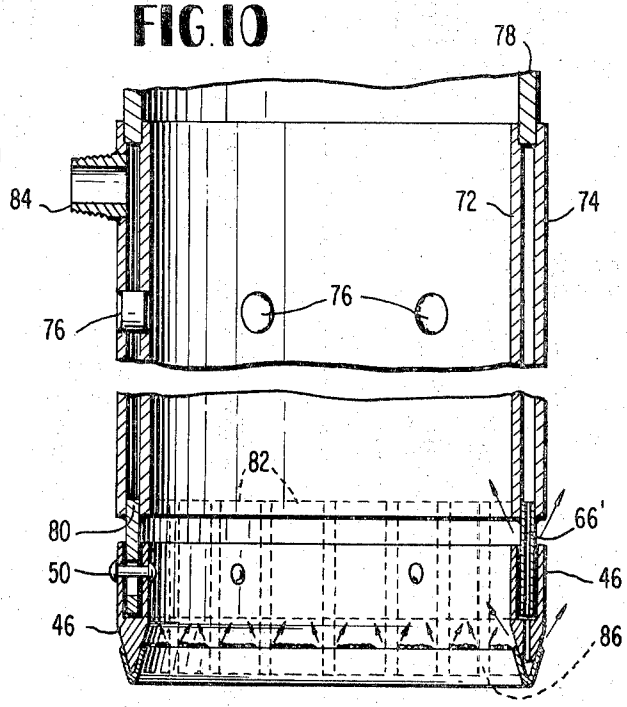


FIG. 11

FIG. 10



JET SHEET AND CIRCULAR PILE WITH WATER HAMMER ASSIST

BACKGROUND OF THE INVENTION

This invention relates to improvements in sheet steel piles which have various sectional configurations and are used to form retaining walls, cut-off walls and cellular coffer-dams and, more particularly, to a method and apparatus for lubricating the working surface of the pile as it is being driven.

It is well known to those experienced in the driving of sheet pilling that earth strata varies from pure sand to dense clay with some cobbles. Furthermore, it has been determined that when a driven pile tip severs a clay strata, the residual moisture is driven away from the clay nearest the sheet pile surface causing greater adhesion than normal, and thus reduces and hinders the piercing ability of the sheet. Also, it has been learned that the wedging or binding effect of the soil that becomes locked in between the sheet pile tongue and groove members likewise absorbs driving energy and is likely to cause such heat to be generated that it melts the tongue and groove joint.

There are several different systems for driving sheet piles, one being an automatic impact hammer, and the other a high frequency vibrator that sets a standing sinusoidal force wave which has no side motion and the latter system has proven to be about ten times faster than the former method and is particularly useful in soil strata formations that are more or less granular. Due to the high impact force of the automatic hammer, which is generally six times that of the high frequency vibrator in clay strata, the top and bottoms of the pile become bent and curled over and the interlocking elements spread and are ruptured. Also with the automatic impact hammer extraction of sheet piles as the temporary placement for a period of time which has caused rust to develop causes extreme difficulties and sometimes it is impossible to remove them, thus causing a loss of the pile or portions thereof and incurring expensive underwater cut-off work.

The present invention has particular applicability for use either with the automatic impact hammer or the high frequency vibrator, the latter having had certain shortcomings since it was limited more or less to soil strata formations that are more or less granular. Because the high frequency vibrator had certain drawbacks in its use with different types of soil, excessive amounts of force have been developed but increase range has been limited to 5–10 percent. Thus, this improvement by alleviating or reducing soil strata adhesion to the sheet pile surface through the use of properly placed water jets broadens the use of the high frequency vibrator to include the entire range of sheet pile driving.

The prior art directed to improvements in piling which has been concerned with some form of lubrication to achieve entry of the piling into the ground, as well as its possible subsequent later removal therefrom is disclosed in Bignell U.S. Pat. No. 1,024,822, issued Apr. 30, 1912 and Langworthy U.S. Pat. No. 1,588,754, issued June 15, 1926.

In the earlier of these patents is disclosed a piling constructed of a plurality of stacked perforated chambers with an interior piping system being arranged to feed lubricant through the apertures so that the box-like pile can be lowered into the earth under its own weight. In the later patent there is shown a drivable concrete pile that is provided with an embedded piping system and a form of interlock for serially driving piles, the arrangement being such that two lubricant jets are directed downwardly and a divergently disposed third jet is made available for forcing water into the channels of an adjacent previously set pile so that the soil will be removed therefrom and the next driven pile will be successfully interlocked with the earlier driven pile.

Accordingly, the principal object of the invention is to provide a system of controlled lubrication of the driven ends and longitudinally extending surfaces of all sheet steel piling.

Another object of the invention is to provide a system of preventing damage to the interlocking portions of adjacent sections of steel piling while they are being driven by causing the soil that enters the interlock to be maintained in a viscous condition.

Still another object of the invention is to provide a system of driving sheet steel piling which requires a less powerful driving force to be employed to penetrate the soil strata thereby making it more economical to drive sheet piling.

Yet another object of the invention is to provide a system of lubrication for the sheet steel piling that not only enables the pile to be more quickly driven into the earth strata, but also to be extracted therefrom by a vibrator or automatic impact extractor.

A further object of the present invention is to provide a system by which standard mill rolled sheet steel pile sections can be converted to perform the function revealed herein by simple welded fabrication methods as well as to also permit the possibility of a steel rolling mill to form the linear ducts or conduits thus reducing the overall sheet pile cost.

A still further object of the invention is to provide an inexpensive system of forming longitudinally extending channel means on the opposite surfaces of a sheet steel piling where the channel means includes oppositely disposed spaced jets that are adapted to emit a fan-shaped spray pattern over the respective surfaces of the sheet piling.

An additional object of the invention is to utilize a loose fit reciprocable drive shoe on the bottom of a section of pile which functions to assist the drive of the vibrator force with a further force known as water hammer, a phenomena that is well known and is capable of developing a shock force up to ten times the pressure of the lubricant being pumped.

Another further object of the invention is to increase the working range of, as well as reduce the power requirements of, the vibrator and as a consequence to more fully achieve noise abatement during the pile driving operation.

These and other objects are achieved according to the present invention by the provision of means for transporting liquid along the body portion of a pile to a drive shoe operatively associated therewith, with the drive shoe having a plurality of jets arranged to permit controlled expulsion of liquid from the drive shoe and in a generally upward direction along the outer surface of the drive shoe to assist in lubricating the drive shoe and the surrounding portion of the pile when the pile is driven.

BRIEF DESCRIPTION OF THE DRAWING

Further objects and advantages will become more apparent from a reading of the following specification taken in conjunction with the drawing.

In the drawing:

FIG. 1 is a combined cross-sectional and elevational view of a section of sheet piling incorporating the invention therein;

FIG. 2 is an exploded front elevational view of a section of sheet piling which discloses a dual duct system of the type shown in FIG. 1;

FIG. 3 is a further embodiment showing in combined cross-sectional and elevational views a variation of the invention as applied to a section of sheet piling of different configuration;

FIG. 4 is an elevational view of the lower portion of the sheet piling of FIG. 3 incorporating a drive shoe;

FIG. 5 is an elevational view of another type of sheet piling incorporating a single duct lubricant flow system;

FIG. 6 is a cross-sectional view on line 6—6 of FIG. 5;

FIG. 7 is an elevational view of a portion of the single duct sheet piling showing the lubricant inlet chamber;

FIG. 8 is a cross-sectional view on line 8—8 of FIG. 5;

FIG. 9 is a cross-sectional view on line 9—9 of FIG. 5; and

FIG. 10 is a cross-sectional view through a section of a circular pile.

FIG. 11 is an elevation of a vibrator clamped to sheet piling.

DETAILED DESCRIPTION

Turning now to the drawings that form the disclosure of this application, particular attention is directed to the fact that the manifolds disclosed herein and which are adapted to be associated with the duct system extending longitudinally of the sheet piling may be used with any of the well-known types of sheet piling, such as flat, "Z" or deep arch.

The first embodiment of the inventive concept disclosed is best seen in FIG. 1, which is a cross-sectional view of a section of a sheet piling 10 of "Z" configuration. This type of sheet piling is provided at the time of manufacture or subsequent thereto, e.g., by drilling with a row of uniformly spaced apertures 11—11 at the point of angulation of the parallel oppositely extending wings as shown, and these series of apertures which extend substantially the length of the sheet piling are covered by skip welding an arcuate plate 12 thereover with the edges of the curved plate 12 being so designed and arranged relative to the planar surface of the sheet of piling that a fan-shaped liquid spray is emitted laterally therefrom between the unwelded areas (orifices) and generally toward the opposite edges of the section of piling. This water flow is shown in dotted outline on the surface of the sheet. It is to be understood that the upper edge of these arcuate plates are fastened securely to the sheet piling to prevent leakage. The apertures 11—11 which extend through to the opposite inner portion of the section of piling are also covered with arcuate members, as shown, and these members 13—13 also are skip welded thereto in spaced relation along the longitudinal extent thereof and in such a manner as to provide another series of oppositely directed jets through which fan-shaped sprays of lubricant may be emitted transversely of the planar surface of the section of of piling.

For reasons that will be apparent to those skilled in the sheet piling art and its use, the duct manifold for feeding the lubricant to the opposed channels 12—12 and 13—13 will be positioned at a point below the upper extremity of the section of piling so that it will not be damaged during handling.

With further reference to FIG. 1, and since the several duct manifolds are identical only one will be described. The manifold generally indicated at 15 is formed by securely positioning, e.g., by welding a plate 16 at one end thereof to the section of piling adjacent to the interlocking groove 17 and at its opposite end to the intermediate web portion 10' of the Z-shaped piling 10.

By now referring to FIG. 2 it will be seen that plate 16 is adapted to be welded to the top of the arcuate member 12 and to have secured to the lower surface thereof the edge of a plate 18 and to the upper surface thereof a plate 20, thus completely closing in the area adjacent to the upper extremity of the feed lines to provide a lubricant chamber 22. The chamber 22 is fed lubricant through a threaded spud 24 which has means defining openings therein as shown at 26—26, access to the spud being provided by perforating the section of the wall of the piling, as shown in 30, and the front wall of closure member 16 by providing the perforation 32 therein. This threaded spud facilitates assembly of the water connection fitting with the manifold from either side it being understood that the unused opening in the spud will be furnished with a closure plug, not shown.

FIG. 3 shows another concept for a lubricant manifold adapted for feeding the channels 12—12 and 13—13, as explained earlier in connection with FIG. 1.

In the embodiment of FIG. 3 a plate 16' is arranged to be welded at 34 to the plate 36, as shown, and is provided at its opposite end with a filler means 38 and together with top and bottom closure plates (only one shown at 39) the manifold chamber is completely enclosed with access thereto being achieved by means of the nipple 40 that is positioned in an aperture 42 in the web as at 44. As explained earlier in connection with the description of FIG. 1, the water hose connection is made to the nipple 40 thereby feeding the lubricant through the perforations 11—11, whereupon the fan-shaped spray is emitted laterally of the surface area of the sheet piling toward the interlocks at the opposite edge portions thereof as explained earlier in the description of FIG. 1.

FIG. 4 shows the lower extremity of the sheet pile element 10 with the duct members terminating into a reciprocable drive shoe means 46, the assembly of which with the sheet piling is best shown in FIG. 5, all of which will now be described in greater detail.

In FIG. 4 there is shown a front elevational view of a portion of a section of the sheet piling 10 into which the present inventive concept is incorporated and the drive shoe means 46 with the portion of the drive shoe removed to reveal its assembly with the sheet piling.

The sheet pile 10 is provided with a plurality of uniformly spaced vertically extending slots 48—48 which

are adapted to receive the shank portions of rivets **50-50,** these being best shown in FIGS. **5** and **6.**

The drive shoe means **46** is arranged to slide freely adjacent to the terminal surface of the sheet piling **10** and to thereby permit the lubricant which is transmitted to the shoe to travel laterally along the channel **52** (see FIGS. **4** and **5**) and upwardly on adjacent sides of the sheet piling as well shown in FIG. **6.** It will be noted from the view of FIGS. **4** and **5** that a series of feed ports **54—54** transmit lubricant downwardly through the interior of a V-shaped hard metal tip **56** to a secondary channel **58** formed therein. The hard metal tip **56** is skip welded to the shoe **46** and adapted to extend the full width thereof, the arrangement of the shoe with the sheet piling and the hard metal tip with the shoe being such that the force of the lubricant during driving of the sheet piling is not only emitted along the top edge of the shoe in the vicinity of its contact with the shoe with the sheet piling, but also is caused to jet upwardly between the skip welded areas of attachment of the hard metal tip with the shoe and thus travel over the drive shoe.

The inventive concept as thus far disclosed reveals dual longitudinally extending duct elements that are secured to the web of sheet piling and arranged to feed lubricant laterally through fan-shaped jets (orifices) and over the web of the sheet piling as well as to the bottom area of the piling then through first and second channels positioned between the drive shoe and the hard metal tip that is welded thereto.

It is also to be understood that a dual duct system is not to be considered limitative of the preferred manner of delivering water to the web of the sheet piling and the drive shoe, for as shown in FIGS. **5** and **7** a single duct element may be utilized for feeding lubricant in a desired manner and to the areas of the sheet considered to be critical to a successful driving operation.

FIG. **7** shows a front elevational view of a sheet piling **10** of any of the earlier discussed types that is provided with a manifold **60** completely enclosed on opposite sides of the web and provided with a central perforated area **62** either of which may be plugged while the other is used for the water connection. The duct **64** which descends to the bottom of the piling may be of any suitable cross-sectional configuration.

FIG. **8** is a cross-sectional view on line **8—8** of FIG. **5** and shows the manner of assembly of the floating drive shoe **46** with the piling **10,** all of which will be clear from the earlier description of FIG. **4.** The drive shoe is secured to the sheet piling so as to reciprocate relative thereto and the primary and secondary channels are fed the lubricant in the manner as described earlier herein.

FIG. **9** is an enlarged cross-sectional view on line **9—9** of FIG. **5** and clearly depicts the piling at **10,** the respective portions of the duct element **64—64** to form the cylindrical feed channel for transporting the lubricant to the annular throat member **66** which is welded as at **68** to the duct **64** and terminates in a loose fit within the bore **70** of the drive shoe **46** so that water may be emitted upwardly toward the duct **64,** as illustrated by the arrows. During the up and down vibratory motion of the sheet steel piling while it is being driven, the throat member or nipple **66** through which water is fed to the drive shoe **46** is caused to open and close against the bottom of the bore **70** causing the flow of water to be blocked from emission and thereby creating a water hammer effect. Water hammer is well known and is the concussion which results when a moving volume of liquid in a pipe is suddenly arrested.

Accordingly, since this system of driving steel piling irrespective of its configuration utilizes a loose fitting drive shoe at the bottom of the section of piling, this provides together with the water or lubricant introduced to the shoe and the vibrator force for driving the piling a still further force known as water hammer, a phenomena that develops a shock force up to 10 times the liquid pump pressure.

As previously mentioned, to develop such a water hammer effect, it is merely necessary to momentarily stop the flow of liquid suddenly. This is achieved by the vibrator's standing wave motion which jams the nipple **66** down against the bottom of the bore **70** in the drive shoe during the downward portion of pile excursion. This sudden blockage sets up a shock wave which has a pressure of about 3,000 psi in about 1/400 of a second and is fast enough to assist the force of the vibratory driver operating at about 15 cycles per second.

FIG. **10** is another embodiment of the invention wherein the inventive concept is applied to a circular pile.

In FIG. **10** there is shown a view of a circular pile which is constructed of spacedly arranged concentric walls **72** and **74** that are adapted to be held throughout their length in a rigid driving relation by plug weld spacer means **76** and further arranged to have welded thereto at their upper extremity an annular vibrator ring **78.** The lower portion of the pile is closed as at **80** by welding slotted vertical extension pieces **82** which can support by means of the rivets described earlier in connection with FIGS. **4** and **5** the drive shoe **46.** The pile is provided with a nipple **84** which is seated in a perforation in the outer wall **74** of the circular caisson and to which the hose may be attached during the driving operation. Water thus circulates through the circular pile and downwardly through parts **66'** provided by the slotted members **82** and thence into the drive shoe and downwardly therethrough into the V-shaped hard metal tip which is skip welded around the perimeter of the drive shoe in such a manner that orifices will be provided at **86** for jetting water passing through the shoe upwardly, as described in connection with FIGS. **4, 5** and **6.** Water passing through parts **66'** is also jetted upwardly along the top edge of the shoe in the manner described in connection with FIGS. **4, 5** and **6.**

It is believed to be apparent in view of the description of the water hammer phenomena availed of in connection with the sections of sheet steel piling described earlier that this same concept can also be used in the circular caisson and attention is directed to the similarity of construction at the right-hand corner of FIG. **10** when it is compared with FIG. **9.** It will be noted that the nipple **66'** extends downwardly into the shoe **46** in the same manner as shown in FIG. **9** with the shoe **46** being secured in a reciprocable arrangement relative to the circular caisson.

FIG. **11** illustrates how a vibrator may be clamped to the top of the piling. A commerciably available vibrator **90,** only a portion of which is shown is provided with a hydraulic cylinder **91** for operating one of a pair of clamping jaws which receive between them the upper edge of the piling to be driven. The jaw operated by the hydraulic cylinder having a piston rod **91a** with a piston, not shown, in the cylinder. In order to use such a

vibrator with the piling of this invention special clamping jaws are preferably provided as described below.

In FIG. **11** piling **92** is shown having a manifold **93** with openings on each side connected by a spud **94** having openings in its side wall. Duct **95** on the piling communicates with manifold **94** for purposes described heretofore. Jaw **96** has a sealing ring **97** which seals the opening in the manifold on the side of that jaw. Jaw **98** operated by the hydraulic cylinder has a recessed portion **99** for receiving the manifold **93** and a sealing ring **100** on side **101** of the recess for sealing the adjacent opening in the manifold. A nipple **102** is welded to wall **103** of recess **99.** The nipple **102** is screw threadidly connected with a water hose **104** and connects said hose with perforated spud **94** positioned in the manifold.

The vibrator is thus securely clamped to the piling which at the same time a sealed connection of the water hose to the manifold is provided so that water supplied to the hose enters the manifold and then the duct **95** for purposes heretofore described. Suitable modifications of the clamping jaws may be made to accommodate the various types of manifolds and piling which may be used in the practice of the invention.

It is believed to be apparent from the foregoing disclosure that those skilled in the art will conceive of variations for not only transmitting the water the full extent of the web as to the drive shoe; however, the disclosure herein is considered to be limited only by the claims appended hereto.

That which is claimed is:

1. A pile comprising, a body portion having a terminus, means associated with said body portion for transporting a supply of liquid relative thereto, a drive shoe, means supporting the drive shoe in spaced relation to the terminus of said body portion, means operatively connected to said transporting means for conducting the supply of liquid to the drive shoe, and a plurality of jets formed in the drive shoe and arranged to permit controlled explusion of liquid from the drive shoe and in a generally upward direction along the outer surface of the drive shoe to assist in lubricating the drive shoe and the surrounding portion of the pile when the pile is driven.

2. A pile as claimed in claim **1,** wherein the drive shoe includes a complementally formed driven tip portion.

3. A pile as claimed in claim **1,** wherein at least one plurality of the jets are positioned between the drive shoe and the terminus of said body portion.

4. A pile as claimed in claim **3,** wherein the jets are disposed at an upper surface of said drive shoe.

5. A pile as claimed in claim **3,** wherein the jets are disposed at a lower surface of said drive shoe.

6. A pile as claimed in claim **2,** wherein at least one plurality of the jets are positioned between the drive shoe and the driven tip portion.

7. A pile as claimed in claim **1,** wherein the means supporting the drive shoe in spaced relation to the terminus of said body portion is such that the drive shoe is movable relative to the body portion of said pile.

8. A pile as claimed in claim **1,** wherein a body portion of said pile is a circular double wall structure.

9. A pile as claimed in claim **1,** wherein the pile has a deep arch and includes longitudinally extending edge portions provided with interlockable tongue and groove means.

10. A pile as claimed in claim **1,** wherein the pile is flat and includes longitudinally extending edge portions provided with interlockable tongue and groove means.

11. A pile as claimed in claim **1,** wherein the pile is of "Z" configuration and includes longitudinally extending edge portions provided with interlockable tongue and groove means.

12. A pile as claimed in claim **1,** wherein at least a portion of the means associated with said body portion for transporting the liquid supply is integral therewith.

13. A pile as claimed in claim **1,** wherein the means associated with said body portion for transporting the liquid supply comprises conduit means that are welded to said body portion.

14. A pile as claimed in claim **1,** wherein the means supporting the drive shoe in spaced relation to the terminus of said body portion is such that the drive shoe can be reciprocated with respect to the terminus of the body portion of the piling and the drive shoe has means which intermittently block the means for conducting said supply of liquid to the drive shoe when the pile is vibrated to thereby create a water hammer effect.

15. A pile comprising, a body portion having a terminus, and means associated with said body portion for transporting a supply of liquid relative thereto, said transporting means including means serving to move the liquid longitudinally of the extent of the body portion and jet means for emitting a portion of the liquid in a direction transverse of the body portion and along the surface thereof to assist in lubricating the body portion in the vicinity of the jet means when the pile is driven.

* * * * *