

☒ Description : paged to paged
☒ Claim(s) : paged 21... to paged 27...
☒ Drawing(s) : paged 1/4... to paged 4/4...
☒ Abstract : paged to paged 1

This Sheet Has Been Replaced



1603491-3

1 CONTROLLING THE ENVIRONMENT AROUND A SUBMERGED PILE OR
2 OTHER STRUCTURES BY ENCAPSULATION, AND TREATING AND
3 REPAIRING THE ENCAPSULATED AREA

4 BACKGROUND OF THE INVENTION

5 1. Field of the Invention.

6 This invention relates to controlling the
7 environment about an underwater pile or other structure. More
8 particularly, the invention relates to a process for
9 controlling the environment about an underwater or submerged
10 pile and applying various preservative techniques to reduce
11 deterioration of the pile due to wave action, tides,
12 corrosion, insects, marine animals and so forth.

13 2. Description of Related Art

14 Piers, off-shore oil platforms and the like are
15 customarily anchored and supported by steel piles that are
16 driven deep into the sea floor. These piles are typically
17 steel pipes that may range in diameter from a few inches to
18 a several feet. They may be very long.

19 In some applications wooden piles are used. Wooden
20 piles are typically treated with a preservative to extend
21 their lives, but they also suffer deterioration from rot,
22 boring animals and the like, which normally extends from the
23 top of the pile to the mud line. Sheet piles are also
24 frequently used, most commonly to prevent erosion of a shore
25 line.

26 These three forms of piles, that is, steel piles,
27 wooden piles, and sheet piles, as well as other underwater
28 structures will be referred to collectively as "piles" herein.
29 The piles corrode or otherwise deteriorate and attract
30 destructive marine life, such as barnacles. The portion of
31 the pile that is sunk into the sea floor typically does not
32 corrode much because there is very little oxygen available
33 there. Further, as the water becomes deeper, there is less
34 oxygen in it and less corrosion or other deterioration.

35 The portion of the pile that is subjected to wave
36 action and tides, that is, the portion relatively close to the



1 surface, suffers from significant corrosion or other
2 deterioration, which significantly shortens the life of such
3 structures. This splash zone usually does not exceed forty
4 feet, even in areas such as the North Sea. Accordingly, forty
5 feet is frequently the longest portion of a pile that would
6 be protected. Protecting the splash zone of piles is
7 particularly important because the repeated wetting and drying
8 of the pile accelerates corrosion and other deterioration,
9 especially in salt water.

10 In the case of wooden piles, boring marine animals
11 and other deterioration typically affects the pile throughout
12 the length from the top of the pile to the mud line and this
13 entire length should be treated. Further, wooden piles should
14 be repaired and strengthened, especially when significant
15 damage has been done to them.

16 Efforts to address these problems have led to a
17 number of proposed solutions in the related art. Many of
18 these efforts to prevent or reduce that corrosion are largely
19 ineffective over the long term. They include, for example,
20 wrapping the piles with gauze-like material saturated with
21 heavy petroleum or grease, which can wash away, leaving the
22 pile unprotected and polluting the environment. Other
23 coatings are applied underwater after the pile has been
24 installed. Some of these proposed solutions have led to
25 patented inventions. The related art known to the inventor
26 is discussed below.

27 U.S. Patent Number 4,993,876, issued to Snow et al.,
28 discloses a "Method and Apparatus for Protective Encapsulation
29 of Structural Members" which involves applying a jacket to the
30 desired portion of a pile and injecting a two part reactive
31 polymer mixture into the jacket. A different color can be
32 included in each polymer component to form a third color when
33 the two components mix, allowing visual monitoring of the
34 degree of mixing and the distribution of the mixture when a
35 transparent or translucent jacket is used. The components are
36 mixed outside of the jacket. The jacket is sealed at the
37 bottom and the polymer (such as epoxy) displaces the water
38 from inside the jacket as it is injected. Prior to
39 installation of the jacket, the pile must be cleaned twice by



1 hand and a biological inhibitor solution may be injected into
2 the jacket prior to grouting. No details are disclosed
3 regarding the seal at the bottom of the jacket. Standing
4 water in the installed jacket is not removed except when
5 displaced by the polymer mixture, which includes three
6 principal components in the preferred embodiment and
7 apparently does not expand as it cures. U.S. Patent
8 Number 4,983,072, issued to Bell, Jr., discloses a "Method of
9 Protecting Submerged Piling" in which a pile is surrounded by
10 a flexible sheet of plastic that is resistant to ultraviolet
11 radiation. The sheet is porous. It forms a space around the
12 pile. That space is filled with a filler material, such as
13 sand and silt, which, according to the patent, keeps marine
14 pests from boring into the pile. Bell, Jr. '072 does not
15 disclose the manner of attachment of the sheet to the pile.
16

17 U.S. Patent Number 4,764,054, issued to Sutton,
18 discloses a "Piling-Jacket System and Method" in which a split
19 jacket is held in place by a steel band at each end. A zipper
20 is used to close the lengthwise split in the jacket. The
21 steel bands are seated in notches or grooves cut into the
22 pile. These grooves weaken the pile. A rigid access tube is
23 inserted through an open port in the jacket for injecting
24 grout. It appears that concrete is the grout of choice.
25 Standing water within the jacket is not removed prior to
26 filling the space with grout, but is merely displaced by the
27 incoming grout, which must be injected in two stages, with
28 some curing allowed prior to the second injection to prevent
29 leakage at the bottom of the jacket. Waiting for some grout
30 to cure before completing the job increases both the labor and
31 capital costs.

32 U.S. Patent Number 4,697,957, issued to Hellmers,
33 discloses a "Marine Pile Protective System" in which a split
34 tube of extruded hexeneethylene copolymer is slipped around
35 a pile and the split edges are snapped together. The seam is
36 sealed with a foam polyurethane strip, as is the bottom of the
37 jacket. The jacket can be drawn tightly against the pile by
38 nylon webbing and is held in its final position by aluminum
39 alloy nails. The jacket provides a water and air tight seal



1 around the pile, excluding oxygen from the pile. There is no
2 filler material within the jacket.

3 U.S. Patent Number 4,306,821, issued to Moore,
4 discloses a "Method and Apparatus for Restoring Piling" in
5 which an outer form is attached to a portion of a damaged
6 piling. A filler is placed into the space between the form
7 and the piling. The form is secured to the piling with bands
8 and a space is maintained between the form and the piling by
9 spacers. The filler, preferably epoxy, can be introduced
10 through a filler tube in the lower portion or a second filler
11 tube at the top of the form, the latter of which can be
12 progressively withdrawn as the filler is injected. The method
13 can be used on either wet or dry portions of the piling. No
14 effort is made to dry the piling prior to injection of the
15 filler.

16 U.S. Patent Number 3,736,759, issued to Bloese,
17 discloses a "Pile Covering" in which a sheath is secured to
18 the pile and an expandable filler material is expanded in
19 place between the jacket and the pile to form a closed-cell
20 filler. To develop greater adhesion between the foam and the
21 jacket, the jacket may include friction ribs. The method may
22 also include cleaning the pile, attaching the sheath, which
23 is sealed by a collar below the water line, pumping out the
24 standing water and drying the pile prior to injecting the
25 filler. There is no indication of how these functions are
26 accomplished.

27 These related art efforts to solve the problems of
28 corrosion and other deterioration, however, suffer from
29 serious shortcomings. These methods are difficult and
30 expensive to use. Moreover, they provide only temporary and
31 incomplete solutions to the problems of corrosion and other
32 deterioration, often due to poor adhesion to a pile by any
33 protective material. Many of the coatings fracture when
34 vessels bump into them during berthing, allowing the water to
35 come into contact with the pile again. In this case, the
36 coating may appear to protect the pile when it does not.

37 In another shortcoming, for example, they leave in
38 place any contaminating materials already on the pile.
39 Further, the jacket is left in place on the pile and it cannot
be used again, but it does little to increase protection of



1 the pile. There is no provision in the related art discussed
2 herein for recovering any excess products or waste products,
3 which may be toxic, that may be generated during treatment of
4 a pile, increasing the threat to our marine environments.

5 The sheaths or jackets of these related art
6 references are open at the top, restricting their use to
7 structures that extend above the water line and requiring
8 applications in which the top of the sheath is above the water
9 line. Moreover, the related art discussed herein does not
10 disclose or suggest any apparatus or process for creating a
11 controlled, sealed environment about a portion of a submerged
12 pile. Further, there is no disclosure of a system that can
13 tolerate high pressures that can be necessary to force a
14 coating into cracks and other surface defects of a pile.

15 Accordingly, there is a need for an apparatus and
16 a process for creating a controlled environment about a
17 portion of a pile to be treated and protected. Once a
18 controlled environment is achieved, the space in that
19 environment can be dried, then treated with any desired
20 treatment to prevent further deterioration of the pile, to
21 provide protection from future environmental hazards, to
22 provide protection from impacts, and even to rebuild the
23 structural integrity of the piles. In addition, important
24 contributions to the environment can be made by recovering any
25 excess chemical products or waste products generated during
26 treatment of the piles. Fundamentally, a need exists for a
27 means for creating a controlled, sealed environment about an
28 underwater structure, such as a pile, and treating and
29 repairing that structure, in order to extend the life of the
30 structure at a substantial savings over replacing it.

31 SUMMARY OF THE INVENTION

32 According to one aspect of the invention, there is
33 provided a process for creating a controlled environment about
34 at least a portion of a submerged pile comprising the steps
35 of: securing a jacket having at least one longitudinal seam
36 along a portion of a pile to be treated and sealing said
37 longitudinal seam to encapsulate a space along a desired
38 length of said pile; providing at least one upper valve and

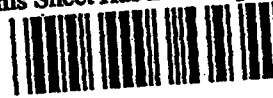


1 at least one lower valve for allowing fluid flows into and out
2 of said encapsulated space; and expelling water trapped in
3 said encapsulated space through said lower valve by injecting
4 a gas into said encapsulated space through said upper valve.
5 According to another aspect of the invention, there is
6 provided an apparatus for treating a submerged pile comprising
7 a jacket having at least two longitudinal sections of arcuate
8 cross section with a sealing means a long each longitudinal
9 edge of each said arcuate section for fastening said sealing
10 means from different said longitudinal sections together along
11 a plurality of seams formed by so joining said edges. The
12 present invention may provide a means for creating a
13 controlled environment about a portion of a submerged pile to
14 be treated. After a controlled environment is created in an
15 encapsulated space along a desired portion of a pile, any
16 treatment method can conveniently be used more effectively
17 because superior adhesion of coatings may be achieved and
18 temperature suitable for proper curing of coatings can be
19 maintained.

20 The invention may also provide a means for creating
21 a controlled encapsulated space about a portion of a pile to
22 be treated that is either partially or wholly underwater, as
23 well as means for encapsulating and treating a joint between
24 two or more underwater members and adjoining portions of the
25 members.

26 Preferably, the invention provides a means for
27 creating a controlled environment in an encapsulated space
28 about a portion of a pile to be treated that can be used in
29 any spatial orientation or with any shape of underwater
30 structure. In one aspect of the invention, there is created
31 a controlled environment about the pile along whatever portion
32 needs to be protected and then that environment is manipulated
33 to protect the pile through any of a variety of treatment and
34 coating techniques.

35 The desired portion of the pile may be enclosed
36 within a tube or jacket having a seal, such as a gasket, or
37 cap at each end. The jacket may be made from plastic or a
38 resilient material such as rubber, which will withstand
39 routine bumping by berthing vessels without breaking. Such



1 jackets are left in place on the pile when the job is
2 finished.

3 Alternatively, in another preferred embodiment, a
4 metal jacket is provided, which may be removed from the pile
5 at the conclusion of a job and reused on subsequent jobs. The
6 jacket and the gaskets or end caps may be sealed along all
7 seams, i.e., relative to each other and to the pile.

8 When the jacket and gaskets or end caps have been
9 installed, a portion of the pile and some surrounding space
10 has been encapsulated. The environment within this
11 encapsulated space can be controlled and manipulated as
12 desired to provide a desired level of treatment, protection
13 and repair of the pile within the encapsulated space.

14 One or more upper valves may be oriented to allow
15 fluids to flow into the jacket and one or more lower valves
16 may be provided in the jacket or end cap at a location remote
17 from the upper valves, typically toward or at the bottom of
18 the jacket. The upper valves may initially carry compressed
19 air into the encapsulated space to force out the water and to
20 dry the encapsulated space. The water is preferably forced
21 out through the lower valves.

22 After drying, the pile is preferably ready for
23 coating. The direction of fluid flow through both the upper
24 and lower valves can be reversed. In applying the desired
25 coating, it is typically admitted into the encapsulated space
26 through the lower valves and the air that is thus displaced
27 and any excess coating material and vapors may be vented
28 through the now reversed upper valve. Typical or preferred
29 treatment regimens include, as example only, the following.

30 Fresh water can be repeatedly introduced into the
31 jacket to flush the jacket and pile and thereby purge any
32 contaminants such as mineral salts from the encapsulated
33 space. Alternatively, commercial solvents can be introduced
34 to flush out contaminants and to prepare the surface of the
35 pile to accept a coating or finish. For example, the surface
36 may be etched, rust removed, and so forth. Any such solvents
37 would be recovered via the outlet valve and a remotely located
38 recovery tank to protect the environment.



1 If desired, a rust inhibitor can also be applied
2 through the jacket, followed by further compressed air to
3 allow the rust inhibitor to dry or cure.

4 Then the jacket may be filled with a firm resilient,
5 non-corroding compound that prevents water from contacting the
6 pile. This can be done whether or not the jacket is left in
7 place when the job is finished. For example, the jacket can
8 be filled with an expanding closed-cell foam formed from
9 liquid chemicals, epoxy resins or the like.

10 When the jacket is to be left in place permanently,
11 the valves are removed and the openings may be sealed without
12 allowing water to infiltrate the jacket. In a preferred
13 embodiment, however, the jacket is removed from the pile after
14 the coating has cured, allowing the jacket, end seals, and
15 valves to be reused.

16 Once the desired portion of the pile is thus
17 encapsulated by a cured coating, very little if any oxygen and
18 no corrosive salts come into contact with the pile, which
19 therefore cannot corrode. Conveniently, this technique
20 protects piles against corrosion better than existing
21 techniques, at lower cost, at reduced risk to the divers, and
22 requires far less labor than existing techniques. It may also
23 protect the environment by recovering toxic waste.

24 This same technique can also be applied to wooden
25 piles,
26 I-beams, concrete piles, sheet piles, and other structures.
27 These techniques can be used to create a controlled
28 environment about piles in an encapsulated space that is
29 completely underwater and may also be used to encapsulate and
30 treat joints between two or more submerged members, regardless
31 of their orientation in space or of the angles at which
32 multiple members meet.

33 Other objects and advantages of the present
34 invention will become apparent from the following description
35 taken in connection with the accompanying drawings, wherein
36 is set forth by way of illustration and example, the preferred
37 embodiments of the present invention and the best mode
38 currently known to the inventor for carrying out his
39 invention.



BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevation partially in section illustrating three submerged piles supporting a pier, with each of the three piles in a different stage of treatment according to the present invention, wherein a jacket is installed on a pile prior to coating.

Fig. 2 is a side elevation partially in section illustrating one embodiment of the present invention.

Fig. 3 is a cross section of a pile prepared for treatment according to one embodiment of the present invention taken along lines 3-3 of Fig. 1.

Fig. 4 is a cross section of a pile prepared for treatment according to another embodiment of the present invention, which is analogous to Fig. 3, but illustrates a different embodiment of the present invention, which utilizes a different style of jacket.

Fig. 5 is a cross section of a pile after treatment according to the present invention taken along lines 5-5 of Fig. 1.

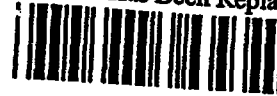
Fig. 6 is a side elevation of the present invention in use on a pile marine structure illustrating use of the invention on completely submerged members and use of the invention on a joint between two submerged members.

Fig. 7 is a side elevation partially in section illustrating the present invention in a preferred coating application mode.

Fig. 8 is a fragmentary cross section along a substantially horizontal line of the present invention in use with a substantially vertical sheet pile marine structure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As required by the Patent Statutes and case law, the preferred embodiments of the present invention and the best mode currently known to the inventor for carrying out the invention are disclosed in detail herein. The embodiments disclosed herein, however, merely illustrate the invention, which may be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely to provide the proper

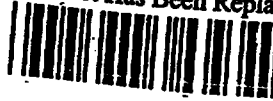


1 basis for the claims and as a representative basis for
2 teaching one skilled in the art to employ the apparatus and
3 processes disclosed herein in any appropriately specific and
4 detailed process or structure.

5 Referring to Fig. 1, there is shown a pile 10
6 treated according to the present invention, which includes a
7 pile 12 made of wood, steel, or other material, that is coated
8 by a coating 14. The pile 12 is submerged in a body of water
9 16. The coating 14 is applied along any desired portion of
10 the pile 12, which preferably includes the splash zone 15,
11 that is, the length of the pile that is subject to wave action
12 from weather and tides, and may further include a depth below
13 the normal water line 17 sufficient to encounter a low level
14 of dissolved oxygen in the water about the pile. The water
15 16 may be fresh water or salt water. The method and apparatus
16 disclosed herein may also conveniently be used to encapsulate
17 and treat areas that are entirely underwater, as discussed
18 below in relation to Fig. 6, 7. Wooden piles will typically
19 be treated from the top of the splash zone 15 to the mud line
20 19.

21 The coating 14 may be any desired coating that
22 provides specific benefits in a particular environment. For
23 example, preventing rust may be a goal of treatment of steel
24 piles, especially in salt water environments. Then any of
25 various epoxy compounds may be preferred.

26 When wooden piles are treated, one goal of
27 treatment may be to prevent wood boring pests from damaging
28 the wood, in which case epoxy, grout, rubber or rubber-like
29 compounds, concrete and the like may be a preferred coating
30 material. Alternatively, the jacket 20 may be filled with an
31 appropriate pesticide, either in a liquid or gaseous state,
32 and the jacket 20 can be sealed by closing the valves 22, 24
33 for a predetermined time required to assure the eradication
34 of the pests. Then the valves 22, 24 are opened and the
35 residual pesticide is exhausted and treated in the recovery
36 tank 38. Then the desired coating is applied as described
37 below.



1 If it is desired to prevent impact damage, an
2 expanding closed cell material, rubber or rubber-like material
3 may be a preferred coating.

4 Still referring to Fig. 1, an apparatus 18 for
5 treating piles 12 includes a jacket 20 secured about the
6 portion of the pile 12 to be treated, an upper valve 22 near
7 the top of the jacket 20 and a lower valve 24 near the bottom
8 of the jacket 20. The valves 22, 24 are installed in the
9 jacket 20 before it is applied to a pile. The upper valve 22
10 and the lower valve 24 permit or allow fluid flow into and out
11 of the encapsulated space 27 and they may be operated to
12 permit fluid flow from the top of the jacket 20 to the bottom
13 of the jacket 20 or from the bottom of the jacket 20 to the
14 top of the jacket 20.

15 This capability allows complete management of the
16 fluid flow at any desired rate and any desired direction. The
17 valves 22, 24 are secured and sealed within apertures in the
18 jacket 20 by welding beads 21, caulking, or other suitable
19 means (see, for example, Figs. 2, 3). The valves 22, 24 are
20 both two way valves that allow fluid flow either into or out
21 of the encapsulated space 27, as selected by the user. The
22 valves 22, 24 can be clamps that pinch the hose closed
23 adjacent to the jacket 20 when desired, or they may be ball
24 valves or the like.

25 Initially, an air hose 26 is connected to the air
26 inlet valve 22 by a coupling 28 at one end and an air
27 compressor 30 at the other end. The lower valve 24 is
28 connected to a discharge hose 32 via a coupling 34, which is
29 routed back above the surface of the body of water 16 and is
30 connected to a recovery tank 38. The direction of the fluid
31 flows in the draining and drying mode of operation is
32 indicated by the arrows 21 in Fig. 2.

33 In most applications air or other gas will be
34 injected through more than one upper valve 22 and the gas or
35 other fluid will flow out of the jacket 20 through more than
36 one lower valve 24. The number of such valves and their
37 distribution along and about the jacket 20 for a particular
38 application depends on factors such as the length of the
39 portion of the pile that will be treated, the volume of water



that must be expelled from the jacket 20, the temperature of the surrounding water, the viscosity and flow characteristics of the coatings or other chemicals to be applied to the pile and so forth. In some applications there may be a large number of such valves, but for simplicity only one of each is shown in the drawing figures. Appropriate baffles may be installed inside the jacket 20 to control the air flow through the jacket 20 as desired, causing the air, for example, to swirl about the pile 12.

During treatment of a pile 12, the water in the encapsulated space 27 between the jacket 20 and the pile 12 is forced out through the lower valve 24 by compressed gas, preferably air, that is introduced through the upper valve 22. Alternatively, the air or other gas can be forced air, as from a squirrel cage blower or other source of forced air connected to suitable ducts. This means of forced air flow can also be used during the drying procedure described below. The discharged water may be returned to the body of water 16 either by disconnecting the discharge hose 32 from the recovery tank 38 or draining the water in the recovery tank 32 itself back into the body of water 12.

The air compressor 28, recovery tank 38 and other equipment and supplies may be conveniently set up on a pier 40, which rests on the piles 12, as shown in Fig. 1. Alternatively, this equipment may be set up on boats, barges, and the like that operate adjacent to the piles to be treated, or on a platform suspended from a pier. This latter technique can be useful when the pier or other platform itself is located far above the surface of the water.

The jacket 20 includes at least one longitudinal axis or edge. When the longitudinal edges of the jacket 20 are brought together, a seam 42 is formed, which allows the jacket 20 to be installed on a submerged pile that has a platform, pier or other structure on top of it. In the preferred embodiment, there are two longitudinal axes or seams 42 located opposite each other across a diameter of the cylindrical jacket 20.

Referring to the middle jacket 20 in Fig. 1, and Figs. 2, 3, in the preferred embodiment, the jacket 20



comprises two metal tube portions, each having a substantially semi-circular or other arcuate cross section with fastening flanges at each lengthwise edge. A jacket of more than two sections may be more convenient to use with especially large diameter piles. In this case, arcuate sections are still preferred, as they provide greater strength than flat sections, for example, eight sections forming an octagonal cross section.

Referring to Fig. 3, the jacket 20 includes two symmetrical tube portions 44, 46, with flanges 48, 50 respectively that run continuously along the length of each tube portion 44, 46. These two tube portions are fastened by a plurality of fasteners, such as nuts and bolts 52, 54 (See also Fig. 1) inserted through corresponding apertures. A rubber gasket 56 is disposed between the flanges 48, 50 before they are fastened together to provide a tight seal between the members.

In the alternative embodiment of the jacket 20 illustrated in Fig. 4, the jacket 20 is a one-piece jacket 20 having a piano hinge 58 running the length of the jacket 20 along a longitudinal axis of the jacket 20 for pivotally connecting the two sections of the jacket 20. Matching flanges 60 are attached to the edges of the jacket 20 opposite to the hinge 58. A gasket 56 is disposed in between the piano hinge members. A gasket 56 is disposed between the flanges 60 prior to fastening the flanges 60 together with a plurality of nuts and bolts 52, 54 distributed along the length of the jacket 20. The gasket 56 along any type of longitudinal seam 42 may be permanently attached to one flange or hinge portion so that the gasket is a permanent part of the jacket 20 and it is not necessary to fit the gasket into place underwater. In either embodiment, the jacket 20 is preferably made of sheet metal core 29 of sufficient strength to withstand the pressures developed in a particular application.

Referring to Fig. 2, the interior surface 23 of the jacket 20 is coated with a permanent coating of a slippery substance 25, such as Teflon (Registered Trademark) low friction coating or Silverstone (Registered Trademark) low



1 friction coating to reduce or prevent adhesion of a coating
2 that is applied to the pile.

3 A coating or layer of heat insulation 37 covers the
4 exterior of the jacket 20. The jacket 20 is removed from the
5 pile 12 after whatever coating 14 that is applied has cured,
6 making the jacket 20 reusable. In some applications it can
7 be expected that the coating will be forced into the
8 encapsulated space under pressures of about 50 pounds per
9 square inch (3.44×10^6 dynes/cm²). A typical application of
10 this type is the application of epoxy resins to wooden piles
11 which have deteriorated or been consumed so that a significant
12 portion of the pile has been destroyed or the surface is
13 severely pocked. In such a case, high pressure forces the
14 epoxy into all the cavities in the pile. The surface of the
15 pile is thus built up to fill voids and to increase the
16 structural integrity and strength of the pile 12.

17 The jacket 20 forms a cylinder about the pile 12.
18 To provide a sealed and controlled environment about the
19 portion of the pile 12 to be protected it is necessary to seal
20 the top end 62 and the bottom end of the jacket 64. How this
21 is done depends on the type of coating that is desired.

22 If a relatively thin coating (e.g., about 1/4 inch;
23 .635 cm) is to be used, for example an epoxy coating, a gasket
24 65, shown in Fig. 4, is installed at the top end 62 and a
25 second gasket 66 is installed at the bottom end 64 of the
26 jacket 20 (See Fig. 2) before the flanges 50 are fastened
27 together. The gasket 64 is made of suitable material such as
28 rubber or a synthetic rubber that will not be significantly
29 degraded during the curing period of the coating. The gaskets
30 64, which may be similar to O-rings, are suitably dimensioned
31 so that they are clamped tightly between the jacket 20 and the
32 pile 12 when the flanges 48, 50, or 60 are fastened together.
33 The gaskets 64 are preferably split into two pieces with
34 overlapping ends, allowing them to be permanently attached to
35 the edges of the jacket 20 by adhesives. This construction
36 eliminates the need to assemble the gaskets and the jacket 20
37 underwater.

38 In an alternative embodiment illustrated in Fig. 2,
39 a thicker coating, such as closed cell foam, silicon based



1 caulking-type material, synthetic rubber, and the like, is
2 used to fill the encapsulated space. A thicker, more shock
3 absorbing coating is desirable when it is important to protect
4 the pile 12 from impact. In this case, the encapsulated space
5 27 between the pile 12 and the jacket 20 is larger and the
6 space between the two elements cannot be sealed by a simple
7 gasket. In such a case a pair of end caps 68 seal the top end
8 62 and bottom end 64 of the jacket 20. The end caps may be
9 made in sections and are sealed by a suitable sealing compound
10 70.

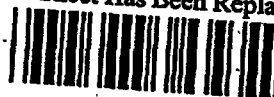
11 Still referring to Fig. 2, the end caps 68 are
12 seated within the ends of the jacket 20, and are drawn into
13 sealing engagement with the jacket 20 when the longitudinal
14 flanges are fastened together. Alternatively, the end caps
15 68 can overlap and extend beyond the outer edges of the jacket
16 20.

17 The process for using the equipment described above
18 is as follows. The pile surface may be prepared according to
19 well known techniques, for example, sandblasting, wire
20 brushing, and so forth, prior to installation of the jacket
21 20.

22 After surface preparation, the jacket 20 is
23 installed by divers, who maneuver the jacket 20 into position,
24 bring the flanges 48, 50 (Fig. 3) or 60 (Fig. 4), as the case
25 may be, together and fasten the flanges 48, 50 together. In
26 the case of a thin coating application, the top end 62 and
27 bottom end 64 of the jacket 20 are automatically sealed by the
28 gaskets 66.

29 In the case of applying a thicker coating using the
30 jacket 20 assembly shown in Fig. 2, the end caps 68 are
31 preferably installed after surface preparation of the pile 12
32 but before the jacket 20 is installed, although the jacket 20
33 can be installed first if desired. In this case, it is
34 advantageous to supply a device for holding the jacket 20 at
35 a desired vertical location.

36 After the jacket 20 is attached to the pile 12, the
37 air inlet hose 26 is connected to the upper valve 22 and the
38 discharge hose 32 is connected to the lower valve 24, or to
39 all upper hoses and all lower hoses when multiple upper and

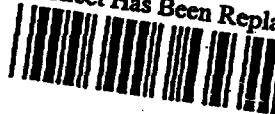


1 lower hoses are used. The other end of the air hose 26 is
2 then connected to the air compressor 30 (Fig. 1). The air
3 compressor 38 is turned on and the water is pushed downward
4 and out of the encapsulated space 27 between the jacket 20 and
5 the pile 12 and is returned to the body of water 16 through
6 the discharge hose 32. Then the encapsulated space 27 is
7 dried by continuing to force air through it. Drying agents,
8 such as alcohol or other chemicals, may be introduced into the
9 air stream, as described below.

10 Referring now to Fig. 6, there is shown another
11 embodiment of the jacket 71, which is used to encapsulate a
12 joint 73 and adjacent piles formed at the junction of the pile
13 members 75, 77. All portions of the treatment areas of the
14 piles 75, 77, and naturally all of the jacket 71 are
15 underwater. The means for emptying, drying and treating the
16 encapsulated space are the same as those described for the
17 other embodiments described herein. At least a second air
18 hose 79 and upper valve 81 are included near the
19 Y-junction of the pile members 75, 77 to facilitate emptying
20 and drying.

21 As clearly shown by Fig. 6, 7, the apparatus and
22 methods disclosed herein can be employed when the entire area
23 to be encapsulated and treated lies wholly underwater.
24 Further, the encapsulation, drying and treatment techniques
25 disclosed herein can be employed regardless of the spatial
26 orientation of the members to be encapsulated and treated in
27 space or relative to one another, whether they are, for
28 example, horizontal, vertical, or at any other orientation to
29 any given reference point. A jacket can be designed according
30 to the techniques disclosed herein for any type of joint or
31 structure.

32 When the encapsulated space is dry, a positive flow
33 of air or other gas is maintained through the encapsulated
34 space 27, providing a dry, stable, controlled environment
35 within the encapsulated space 27. Within this controlled
36 environment, further treatment of the pile 12 can be made as
37 desired with assurance that the treatments will be effective.
38 Superior adhesion and curing of any chemical treatments,



1 coatings and the like result from having a dry, controlled
2 environment.

3 Low temperatures can severely reduce the efficiency
4 of chemical reactions that cure many coatings, such as two-
5 part epoxies, two part foaming mixtures and so forth. Many
6 coatings will not cure properly at low temperatures, but
7 coating work often must be done at low temperatures. In these
8 situations, the air forced into the encapsulated space is
9 preheated by a heater 39 (Fig. 1) and the temperature inside
10 the encapsulated space is monitored by a temperature sensor
11 31, which is connected to a readout device 33 by an electrical
12 cable 35. The heater 39 is connected to the air hose 26 by
13 the heater hose 41 when the apparatus is in the draining and
14 drying mode. The temperature sensor 31 may be directly
15 attached to or embedded in the pile 12 to monitor the actual
16 temperature of the pile 12, which is increased to a desired
17 level, for example, 30 degrees C, to accelerate the curing
18 process of chemical treatments.

19 The layer of heat insulating coating 37 (See Fig.
20 2) on the outside of the jacket 20 helps retain the heat thus
21 transferred to the encapsulated space 27 and the pile 12,
22 further facilitating curing. Applying a coating on both the
23 outside and inside surfaces of the jacket 20, such as the
24 slippery coating 25 on the inside surface of the jacket 20 and
25 the heat insulation 37 on the outside surface of the jacket
26 20, also reduces corrosion of the jacket 20 itself, thereby
27 significantly extending its life. Multi-part chemically
28 reactive coating mixtures normally produce exothermic
29 reactions. When they are injected into a warm insulated
30 environment the temperature necessary for proper curing can
31 ordinarily be maintained even in relatively cold water. The
32 air used for drying the encapsulated space can beneficially
33 be heated to provide dry air for drying the encapsulated space
34 even when heating the pile is not necessary to assist the
35 chemical reactions of the coating. Heating the forced air to
36 speed drying may be especially helpful when relative humidity
37 is high. Further enhanced drying is achieved by using
38 chemical drying agents, such as alcohol and the like.



When the portion of the pile 12 to be protected has been encapsulated, water expelled, dried, and the temperature has been controlled, chemical treatment of the pile can begin. As noted above, in the case of steel piles, it is often desirable to inject a rust inhibitor, or a coating that chemically combines with surface rust, destroying the rust, and simultaneously seals the surface against further rust. When that coating has cured, a second coating, such as a two-part close cell foam material, a multi-part epoxy resin coating, silicon based compound, synthetic rubber, or the like may be applied. Pigments of various colors may be mixed with the epoxy resins or other coatings to provide coated piles having any desired color, which can be used for safety or ornamental purposes and provides a pleasant alternative to the normally drab blacks and browns of most piles.

Alternatively, a rust inhibitor or a coating that combines with rust to seal the surface and prevent further oxidation can be combined with the desired filler coating material, for example, epoxy and the mixture can then be used to fill the encapsulated space 27. Any coating, treatment chemicals, foam, grout, concrete, epoxy, sand, gravel, or other material to be applied to the pile 12 inside the encapsulated space 27 is defined as "filler," whether or not any chemical reaction occurs between elements of the filler or between the filler and the pile.

In the preferred embodiment illustrated in Fig. 7, the coating material enters from the lower portion of the jacket 20 and vapors are vented from the upper portion of the jacket 20. Many types of coatings, for example, expanding foam materials, flow better when introduced from the lower portion of the jacket 20. Therefore, the hose connections, valves and fluid flows are reversed relative to the set up used for draining and drying the encapsulated space.

Still referring to Fig. 7, a coating pump 72 is connected to the hose 32, which becomes a coating hose instead of a discharge hose. The coating pump 72 has suitable characteristics for application of a specific coating. The hose 26 is then connected to the recovery tank 38. The direction of the fluid flows is indicated by the arrows 81.



1 The air compressor 30, and other ancillary equipment (not
2 shown in Fig. 7) used for draining and drying the encapsulated
3 space 27 enclosed within the jacket 20 (shown in Fig. 1) are
4 disconnected and not used for the treatment and coating
5 processes described in relation to Fig. 7.

6 The whole of the encapsulated space 27 is filled
7 with whatever coating will be used. Any vapors, that is, air
8 and entrained matter, rising from the encapsulated space when
9 the coating material is injected are recovered by the hose 26,
10 which conveys excess vapors, products of reaction and so forth
11 from the controlled environment of the encapsulated space 27
12 to the recovery tank 38, which is equipped with suitable
13 filters, condensers, and the like to prevent the release of
14 significant amounts of toxic chemicals and other pollutants
15 into the atmosphere or the water. The entrained matter may
16 include vapors, solids, fluids, and so forth.

17 In the case of a wooden pile 12, the process is the
18 same, but the treatment chemicals may be different. It may
19 be desired, for example, to first treat the encapsulated space
20 with a pesticide that will kill all the marine creatures
21 within the encapsulated space. The controlled environment
22 created in the encapsulated space is especially beneficial in
23 this case because the pesticide can be allowed to remain in
24 the encapsulated space long enough to insure that all the
25 marine creatures are killed. This can be accomplished either
26 by continuing to apply pesticide, or by applying a measured
27 dose of pesticide, then sealing the air hose 26 and the
28 discharge hose 32 at convenient points and allowing the
29 pesticide to remain in the encapsulated space for a
30 predetermined time. The use of the recovery tank 38 to
31 recover such vapors can be especially beneficial to the
32 environment in this case. Following pesticide treatment,
33 other desired coatings may be applied as discussed above.

34 Referring to Fig. 8, there is shown a fragmentary
35 cross section taken along a substantially horizontal line
36 through a substantially vertical sheet pile 80 comprising a
37 plurality of corrugated interlocking sections, of which
38 sections 82 include a male joint 84 and sections 86 include
39 a female joint 88. Each section 82, 86 is typically about two



1 feet long. The sheet pile 80 is typically driven into the mud
2 near the shore line 90 and the space between the sheet pile
3 80 and the shore line is back-filled with filler material 92,
4 such as concrete, gravel, earth, and so forth. A pier or
5 other structure can be built on top of the sheet pile 80 and
6 filler 92. A jacket 94 of sheet metal or the like is designed
7 to be installed roughly parallel to the sheet pile 80 and
8 preferably includes corrugations 96 substantially matching
9 those of the sheet pile 80 to provide greater strength in the
10 jacket 94. The jacket 94 is installed and sealed as described
11 above. The equipment and processes for treating the sheet
12 pile 80 are as described above. It is to be understood that
13 while certain forms of the invention have been illustrated and
14 described herein, the invention is not limited thereto, except
15 insofar as the limitations are included in the following
16 claims.



C L A I M S

1
2 1. A process for creating a controlled environment
3 about at least a portion of a submerged pile comprising the
4 steps of:

5 a. securing a jacket having at least one
6 longitudinal seam along a portion of a pile to be treated and
7 sealing said longitudinal seam to encapsulate a space along
8 a desired length of said pile;

9 b. providing at least one upper valve and at least
10 one lower valve for allowing fluid flows into and out of said
11 encapsulated space; and

12 c. expelling water trapped in said encapsulated
13 space through said lower valve by injecting a gas into said
14 encapsulated space through said upper valve.

15 2. A process in accordance with claim 1 further
16 comprising the additional step of drying the encapsulated
17 portion of said pile by further injecting a gas into said
18 first valve and maintaining a flow of gas through said
19 encapsulated space until said encapsulated portion of said
20 pile is dry.

21 3. A process in accordance with claim 1 wherein
22 said gas comprises air.

23 4. A process in accordance with claim 3 wherein
24 said gas comprises heated air.

25 5. A process in accordance with claim 1 further
26 comprising the additional step of flushing said encapsulated
27 space with fresh water following step c to purge contaminants
28 from said encapsulated space prior to further treatment.

29 6. A process in accordance with claim 5 further
30 comprising the additional steps of treating said encapsulated
31 space with chemicals to stabilize existing corrosion and to
32 kill marine pests.

33 7. A process in accordance with claim 1 further
34 comprising the step of sealing the top and bottom of said
35 jacket relative to said pile.



1 8. A process in accordance with claim 1 further
2 comprising the additional step of filling said encapsulated
3 space with a filler material to forestall further
4 deterioration of said encapsulated portion of said pile.

5 9. A process in accordance with claim 8 wherein
6 said step of filling said encapsulated space further comprises
7 filling said encapsulated space with a closed cell foam
8 material.

9 10. A process in accordance with claim 8 further
10 comprising the step of reversing the direction of fluid flow
11 through said jacket prior to filling said encapsulated space.

12 11. A process in accordance with claim 8 further
13 comprising the additional step of recovering waste products
14 and vapors from said filler material by collecting them and
15 conveying them to a holding tank.

16 12. A process for treating at least a portion of
17 a submerged pile comprising the steps of:

18 a. securing a jacket having at least one
19 longitudinal seam along a portion of a pile to be treated and
20 sealing said longitudinal seam to encapsulate a space along
21 a desired length of said pile;

22 b. providing at least one upper valve and at least
23 one lower valve for allowing fluid flows into and out of said
24 encapsulated space;

25 c. sealing the top and bottom of said jacket
26 relative to said pile;

27 d. expelling water trapped in said encapsulated
28 space through said lower valve by injecting a gas into said
29 encapsulated space through said upper valve; and

30 e. drying said encapsulated portion of said pile
31 by further introducing a gas into said upper valve and
32 maintaining a flow of gas through said encapsulated space out
33 of said lower valve until said encapsulated portion of said
34 pile is dry.

35 13. A process in accordance with claim 12 further
36 comprising the step of heating the air prior to introducing
37 it into said encapsulated space.



1 14. A process in accordance with claim 12 wherein
2 step e further comprises filling said encapsulated space with
3 a filler, which displaces the air inside said encapsulated
4 space.

5 15. A process in accordance with claim 14 further
6 comprising the step of reversing the direction of fluid flow
7 through said jacket prior to filling said encapsulated space.

8 16. A process in accordance with claim 14 further
9 comprising the additional step of recovering and treating said
10 gas and entrained matter that are displaced from said
11 encapsulated space by said filler by collecting it at said
12 upper valve and conveying it to a recovery tank.

13 17. An apparatus for treating a submerged pile
14 comprising a jacket having at least two longitudinal sections
15 of arcuate cross section with a sealing means along each
16 longitudinal edge of each said arcuate section for fastening
17 said sealing means from different said longitudinal sections
18 together along a plurality of seams formed by so joining said
19 edges.

20 18. An apparatus in accordance with claim 17
21 further comprising a low friction coating on the interior
22 surface of said jacket.

23 19. An apparatus in accordance with claim 17
24 further comprising a heat insulation layer on the exterior
25 surface of said jacket.

26 20. An apparatus in accordance with claim 17
27 further comprising means for sealing said seams.

28 21. An apparatus in accordance with claim 17
29 further comprising a hinge means joining at least two said
30 longitudinal sections.

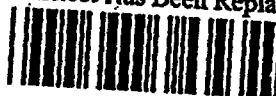
31 22. An apparatus in accordance with claim 17
32 further comprising at least one upper valve and at least one
33 lower valve.

34 23. An apparatus for treating a submerged pile
35 comprising:

36 a. a jacket having at least two longitudinal
37 sections of arcuate cross section with a flange along each
38 longitudinal edge of each said arcuate section, a plurality



This Sheet Has Been Replaced



1 of apertures in each said flange, means for fastening said
2 flanges from different said longitudinal sections together
3 along a plurality of seams formed by so joining said flanges;

4 b. a low friction coating on the interior surface
5 of said jacket;

6 c. a heat insulation layer on the exterior surface
7 of said jacket;

8 d. hinge means joining at least two said
9 longitudinal sections; and

10 e. at least one upper valve and at least one lower
11 valve.

12 24. An apparatus for creating a controlled
13 environment about at least a portion of a submerged pile
14 comprising:

15 a. a jacket for encapsulating a desired portion of
16 said pile, said jacket further comprising at least one upper
17 valve and at least one lower valve;

18 b. means for controlling the direction of fluid
19 flow through said valves and thereby through said encapsulated
20 space;

21 c. means for forcing a gas into said encapsulated
22 space, thereby expelling water inside said encapsulated space
23 and drying it; and

24 d. means for introducing a filler into said
25 encapsulated space.

26 25. An apparatus in accordance with claim 24
27 wherein said jacket further comprises:

28 a. at least two longitudinal sections of arcuate
29 cross section with a flange along each longitudinal edge of
30 each said arcuate section, a plurality of apertures in each
31 said flange, means for fastening said flanges from different
32 said longitudinal sections together along at least one seam
33 formed by so joining said flanges;

34 b. a low friction coating on the interior surface
35 of said jacket;

36 c. a heat insulation layer on the exterior surface
37 of said jacket;



1 d. hinge means joining at least two said
2 longitudinal sections; and

3 e. at least one upper valve and at least one lower
4 valve.

5 26. An apparatus in accordance with claim 24
6 further comprising means for recovering and treating gas and
7 entrained matter that are displaced from said encapsulated
8 space.

9 27. An apparatus in accordance with claim 24
10 wherein said jacket further comprises two sections each having
11 a longitudinal axis and means for pivotally connecting said
12 two sections along said longitudinal axis.

13 28. An apparatus in accordance with claim 27
14 wherein said jacket further comprises means for fastening said
15 two sections together to provide a jacket having a
16 substantially cylindrical cross section.

17 29. An apparatus in accordance with claim 27
18 further comprising means for sealing said jacket about said
19 pile, said pivotal connecting means and said fastening means.

20 30. A process for treating an underwater pile
21 comprising the sequential steps of:

22 a. encapsulating a portion of a pile to be treated
23 to form an encapsulated space about said treatment portion of
24 said pile;

25 b. removing standing water from said encapsulated
26 portion of said pile;

27 c. preparing an exterior pile surface of said
28 encapsulated portion of said pile by circulating surface
29 preparing chemicals through said encapsulated portion of said
30 pile, whereby said exterior surface of said encapsulated
31 portion of said pile will bond with a chemical coating; and

32 d. injecting a coating material into said
33 encapsulated portion of said pile.

34 31. A process in accordance with claim 30 further
35 comprising the additional step of rinsing said encapsulated
36 portion of said pile with a liquid rinsing agent between steps
37 c and d.

This Sheet Has Been Replaced



32. A process in accordance with claim 30 further characterized by selecting said treatment portion of said pile in a splash zone along the length of said pile.

33. A process in accordance with claim 30 wherein step b further comprises injecting compressed air into said encapsulated portion through a controlled opening at an upper end of said encapsulated portion of said pile and thereby forcing the standing water out from a controlled opening at a lower end of said encapsulated space.

34. A process in accordance with claim 30 wherein step d further comprises injecting said coating material into said encapsulated portion of said pile through a controlled opening at a lower end of said encapsulated portion and releasing the air so displaced from a controlled opening at an upper end of said encapsulated portion.

35. A process in accordance with claim 34 further comprising mixing a coating compound having at least two constituent materials that chemically combine and bond to said encapsulated portion of said pile prior to injecting said coating into said encapsulated space in step d.

36. A process in accordance with claim 30 further comprising the additional step of circulating air through said encapsulated space to dry said space between steps c and d.

37. A process in accordance with claim 36 further comprising heating said air prior to circulating said air through said encapsulated portion, whereby said drying is accelerated.

38. A process in accordance with claim 37 further comprising the additional step of maintaining the circulation of said heated air in said encapsulated portion until said encapsulated portion reaches a temperature conducive to proper curing of a chemically reactive coating to be applied in step d.

39. A process in accordance with claim 30 wherein said surface preparation of step b further comprises removing rust and other corrosion from an exterior surface of a metal pile.



This Sheet Has Been Replaced



1 40. A process in accordance with claim 30 wherein
2 the surface preparation of step b further comprises removing
3 encrusted debris and marine creatures from an exterior surface
4 of a wooden pile.

5 41. A process in accordance with claim 39 wherein
6 said surface preparation is carried out using an acid.

7 42. A process for treating an underwater pile
8 comprising the sequential steps of:

9 a. encapsulating a portion of a pile to be treated
10 to form an encapsulated space about said treatment portion of
11 said pile;

12 b. removing standing water from said encapsulated
13 portion of said pile;

14 c. preparing an exterior pile surface of said
15 encapsulated portion of said pile by circulating surface
16 preparing chemicals through said encapsulated portion of said
17 pile, whereby said exterior surface of said encapsulated
18 portion of said pile will bond with a chemical coating;

19 d. rinsing said encapsulated portion of said pile
20 with a liquid rinsing agent; and

21 e. injecting a coating material into said
22 encapsulated portion of said pile.

23 43. A process in accordance with claim 42 wherein
24 step c further comprises inhibiting rusting of a metal pile,
25 thereby arresting further corrosion of said pile.

26 44. A process in accordance with claim 42 wherein
27 step c further comprises acid etching of a metal pile thereby
28 securing better bonding of said coating material in step d.

9 45. A process in accordance with claim 11 further
comprising the additional step f of removing said jacket from
said pile.