

PATENT SPECIFICATION

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- (21) Application No. 11855/78 (22) Filed 23 Mar. 1978
(44) Complete Specification Published 13 Feb. 1980
(51) INT. CL.³ C23F 13/00
(52) Index at Acceptance
C7B 150 273 283 GD
E1H GG
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(19)



(54) IMPROVEMENTS IN OR RELATING TO PILES AND MODULAR PILING SYSTEMS

(71) We, WEST'S PILING AND CONSTRUCTION COMPANY LIMITED, a British Company, of Horton Road, Colnbrook, Slough SL3 OBE, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:

This invention relates to the protection of metallic structures buried in the ground or immersed in a liquid from the effects of corrosion and has a particular, although not exclusive, application in the protection from corrosion of piles and piling systems, particularly modular piling systems in which individual pile sections are interconnected by metallic joints or coupling elements.

In situations where metallic structures or structures incorporating exposed metallic components, such as the metallic joints or coupling elements used in modular piling systems, are buried in the ground or are immersed in a liquid, they are vulnerable to attack by water or aqueous solutions or sulphate-reducing bacteria with resulting corrosion and weakening or eventual rupture thereof.

Such corrosion may be reduced or even prevented, at least for a time, by appropriate treatment of the metallic structure to prevent the moisture which is always present in the ground in which the metallic structure is buried or the liquid in which the metallic structure is immersed, from gaining access to the metal of which the structure is fabricated. With this in view it is common to coat metallic structures with paints or to encase them in protective sheaths or wrappings to prevent corrosion thereof. Whilst such measures may be effective in situations where the coatings, sheathings or wrappings can be inspected, maintained and, where necessary, periodically renewed they can be quite effective but it is evident that in the

case of buried metallic structures or structures driven into a river or sea bed or the like, such as is the case in modular piling systems incorporating metallic joint or coupling elements, these methods of protection do not offer an economically viable or even a practical solution to overcoming the problem of corrosion.

The problem of corrosion is not a serious one in situations where the metallic structures such as modular piling systems, as referred to hereinbefore, can be driven into chalk and gravel but can pose serious problems in other soil conditions such as alluvial or anaerobic conditions. Thus the problem becomes particularly acute in conditions where the piles are to be driven in heavily water logged organic clays and silts such as are encountered, for example, in areas around the London Basin in England, or in other alluvial areas. Corrosion also poses serious problems in situations where anaerobic conditions are encountered where there is substantially no atmospheric oxygen available, and which conditions are conducive to the growth of sulphate-reducing bacterial which utilize the hydrogen formed at the cathode, i.e. at the metallic structure, in this case the metallic pile joints or coupling elements, and thus depolarise the cathode thereby allowing current flow with resultant corrosion of the cathode, i.e. the metallic pile joints or coupling elements.

The present invention has for an object the provision in a pile or in a modular piling system utilizing at least partially exposed metallic joints or coupling elements, of a sacrificial anode that will corrode in place of and protect the metal of the joint or coupling elements and that will do so in both oxidation and also in anaerobic conditions which latter, as noted in the foregoing, are conducive to the formation of sulphate-reducing bacteria which would in the absence of protective measures result in severe

corrosion of the metal of the joint or coupling elements.

With a view therefore, to counteracting, in a practical manner, corrosion arising from oxidation or as the result of sulphate-reducing bacteria, the present invention contemplates the protection of such metallic structures by the use of sacrificial anodes as part of a galvanic system incorporating the pile joints or coupling elements and which anodes will corrode in place of the metal from which the joint or coupling elements are fabricated.

Thus, in a modular piling system for which the present invention is particularly well adapted the individual pile sections are provided at each end with metallic base plates with corner slots, anchor bars fixed to the plates being used to attach the plates to the associated reinforced concrete pile sections and adjoining base plates being coupled by means of metal locking pins driven into the aligned and registering slots at the corners of the coupled base plates. Accurate alignment and centering of adjoining pile sections is effected by means of a locator or centering member adapted to engage in apertures formed centrally of each base plate and each communicating with a recess extending inwardly from said apertures into the adjacent end of the associated concrete pile section.

With this joint or coupling arrangement, upon being driven into the ground or immersed in a liquid the metallic components constituting the joint or coupling elements serve to connect the substance of the ground at different points or different parts of the liquid with which they are in contact, in one or more galvanic circuits with the damp ground, in the case of a buried pile, the moisture in the ground acting as an electrolyte whilst, of course, the liquid media acts as an electrolyte in the case where the pile is driven into a river or sea bed or the like. This galvanic system results in corrosion of the metal of the joint or coupling elements.

To counteract the corrosion inherent in such an arrangement the present invention contemplates the association with each such joint or coupling element of a protective member constituting a sacrificial anode which conveniently may constitute the locator or centering member, which latter ordinarily has the sole purpose of facilitating the locating and alignment of adjacent pile sections prior to their inter-connection by means of locking pins inserted into the slots provided in the base plates of the joint or coupling elements, the protective element e.g. the locator or centering member in accordance with the invention being formed of a metal which in comparison to the metal from which the joint or coupling element is

fabricated is more reactive and exhibits a higher solution potential. It is in fact the potential difference between the reactive metal of which the protective member i.e. the anode is formed and the metal of the joint or coupling elements which provides the current required and which when applied to the joint or coupling elements prevents corrosion thereof, the latter elements acting as the cathode in a galvanic system for which the moisture in the ground or in the liquid medium surrounding the joint or coupling element constitutes the electrolyte.

Preferably the protective member, i.e. the anode, and which as noted may conveniently be constituted by the locator or centering member, is made of zinc although in certain applications it may be possible to use aluminium or magnesium, both of these latter metals, as in the case of zinc, being more reactive than the metal, for example mild steel, from which the joint or coupling elements are normally fabricated and which are to be protected from corrosion.

Preferably, in accordance with the invention, the protective anodic member is constituted by the locator or centering element and is made of zinc, and metallic pieces, bars or rods, of steel or other metal which is less reactive than the metal of which the locator or centering element is fabricated, are cast therein along mutually normal axes thereof, the bars, rods or pieces being interconnected, as by tack welding to ensure a continuous metallic connection between the bars, rods or pieces, the anode proper i.e. the locator or centering element, and the joint or coupling elements, the combination of which in the presence of an electrolyte, such as the moisture in the ground into which the pile is driven or the liquid in which it is immersed, forms galvanic cells. With this arrangement and since the metal of the anode i.e. the locator or centering element, has a greater solution potential than the metal of the joint or coupling elements i.e. the base plates and associated locking pins, there is a sacrificial consumption or dissolution of the anodic locator or centering element whilst the metal of the joint or coupling elements having been rendered cathodic is protected against corrosion.

Suitably one of said bars, pieces or rods extends through the anodic locator or centering element and protrudes from either side thereof, desirably medially of the longitudinal axis and laterally thereof. These protruding portions of the bars, rods or pieces are adapted to be accommodated in one of a pair of grooves formed in one of the abutting surfaces of a pair of mating plates of the joint or coupling elements, which grooves extend away from the central aper-

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ture to the edge of the base plate intermediate, preferably medially, of the diagonals joining opposite pairs of the slots formed in the periphery of the base plate for receiving the joint locking pins. The said one groove is preferably formed intermediate its ends on each side of the central aperture in the plate with an enlarged recess to facilitate the making of a good electrical connection between the anodic locator or centering element and the metal of the base plate as, for example, by welding, suitably by a welding or other electro-thermal joining process. These grooves are designed to be kept open as an electrolytic path for corrosion products formed when the pile with its associated coupling or joint elements is driven into the ground or immersed in a liquid media and the joint or coupling elements are thus buried or immersed in a corrosive environment.

A pile connecting device according to the present invention thus comprises two plates each plate being adapted to be secured to the end of a pile section, each plate having several corners and having a number of recesses extending inwardly from its periphery, there being a recess formed at a selected number of the corners of each plate, each plate having two parallel planar surfaces, one of which is adapted to bear against one of the planar surfaces of the other plate when the plates are brought into abutment, a recess in one plate registering with a corresponding recess in the other plate, and a locking pin adapted to be inserted and retained in a pair of registering recesses, said pin effective to interconnect said plates with said bearing surfaces in abutment, characterised by a protective member electrically connected to at least one of said plates, said protective member serving to align said abutting plates and being made of a metal which exhibits a higher solution potential than the metal of said pile connecting device whereby when said pile connecting device is driven into damp ground or immersed in a liquid the protective member constitutes the sacrificial anode of a galvanic circuit, in which the pile connecting device constitutes the cathode and moisture in the ground or the liquid in which the pile connecting device is immersed constitutes the electrolyte, thereby protecting the pile connecting device from corrosion.

In another aspect of the present invention there is provided a method of protecting metallic pile connecting devices used for interconnecting adjacent sections of a modular piling system, comprising the steps of associating with each of said devices a protective member and effecting a positive connection between said protective member and the metal of said pile connecting device

whereby to provide a continuous electrically conductive path between said protective element and said metal, said protective member being formed of a metal having a solution potential greater than that of the metal of which the pile connecting device is made, whereby the protective member will function as a sacrificial anode in a galvanic circuit completed when said pile connecting device is buried in damp ground or immersed in a liquid either of which acts as an electrolyte, and thus protect the metal of the pile connecting device against corrosion.

With the arrangement according to the present invention the effective life of the metal joint or coupling elements forming part of the modular piling system can be varied by varying the dimensions, particularly the surface area, the weight and other physical characteristics of the sacrificial anode which, as noted, may for example constitute the locator or centering element, said parameters being determined, amongst other factors, by the current requirements to maintain the metal of the joint or coupling elements at the required negative potential in relation to the ground or liquid which surrounds it and of course by considerations of physical limitations or the space available in the joint or coupling elements. These current requirements can in turn be modified and reduced if the joint or coupling elements are pre-treated against corrosion as, for example, by providing some form of physical protection such as a coating of paint, bitumen or other materials, or if they are appropriately sheathed or wrapped. The two types of protection i.e. the physical protection afforded by the coating, sheathing or wrapping and the cathodic protection provided by the anodic locator or centering element being complementary. Thus, the nature of the physical conditions to which the metallic joint or coupling elements are subject, and whether or not they are provided with any physical protection of the types indicated, are amongst the factors determinative of the physical dimensions and characteristics of the sacrificial anode required and of the material of which it is made.

It has been found that in its application to a modular piling system of the type described the provision of a four pound zinc protective member according to the invention is anticipated to provide a life expectation for the structure of the order of fifty years whilst the corrosion-prevention expectation of a sacrificial zinc protective member or anode according to the present invention is such that for protection over a period of some one hundred years in soils exhibiting anaerobic conditions, such as alluvial soils, an eight pound zinc protective member should prove to be more than adequate.

Other features of the invention will be described hereinafter and referred to in the appended claims.

5 The invention will now be more particularly described with reference to an exemplary embodiment thereof as applied to a mechanical joint for use in interconnecting sections of a modular piling system and as shown in the accompanying drawings, in which:-

10 *Figure 1* is a top plan view of a joint or coupling element adapted to be secured at either end of a pile section forming part of a modular piling system;

15 *Figure 2* is a side elevation of a sacrificial anode in the form of a locator or centering member adapted to be inserted into the central aperture of a joint or coupling element as shown in figure 1 and to be secured on the end of one pile section in order to centre an adjacent pile section thereon prior to interconnection of the adjacent pile sections by means of locking pins driven into registering pairs of the corner slots of the joint or coupling elements; and

20 *Figure 3* is an exploded perspective view of a pair of reinforced concrete pile sections having associated joint or coupling elements, as shown in Figure 1, at their adjacent ends for coupling to one another in aligned fashion by means of the sacrificial anodic locator or centering element shown in Figure 2, and the locking pins.

25 Referring to the drawings it will be seen that the modular piling system is formed of a number of reinforced concrete pile sections such as 10 and 12. Adjacent each of the corners of each pile section there are located reinforcing or anchoring bars 14. The individual pile sections are adapted to be interconnected by means of joint units each of which consists of a pair of facing base plates 16, 18 each of which is adapted to be secured to the associated ends of a pile section. In the connecting position the plates 16, 18 bear flatly against each other with contact between their outer planar surfaces 20, 22. The plates 16, 18 are formed with registering recesses 24 at each corner having chamfered edges which are adapted to receive locking pins 28 which, as shown, may be of substantially I-shaped cross-section. In plan each recess 24 includes at least one outwardly flared zone 30 for facilitating the insertion of the locking pins 28. The side walls of each recess 24 are parallel along substantially the entire length thereof with the inner recess wall being at right angles thereto. The zones 30 increasingly diverge outwardly along the outer end of each recess 24 to aid insertion of the locking pins 28. Peripherally extending skirts or sleeves 29 extend normally from the plates 16, 18, respectively, and are

secured thereto in any suitable manner, preferably in a detachable manner so that they may be removed as the respective pile sections proceed into the ground. The skirts or sleeves 29 serve to reduce concrete shattering during the pile driving operation among other functions. The corner of each skirt or sleeve 29 adjacent the recess corners of the plates 16, 18 are also provided with companion recesses 31. One of the plates, 18, is formed with a pair of grooves 32, 34 cut at 45° to the two diagonals interconnecting opposed pairs of the slots or recesses 24. One of the grooves, 34, is enlarged on either side of the central aperture 36 in base plate 18 at 38 and 40 to form recesses for a purpose to be described hereinafter.

A sacrificial anode 42, preferably made of zinc, which also serves as a locator or centering element for aligning adjacent pile sections 16, 18 prior to interconnection of the pile sections by means of the locking pins 28, is in the form of a barrel-shaped plug. Centrally cast in the locator or centering element 42 and extending along the longitudinal axis thereof is a metal bar, piece or rod 44 whose length equals that of the locator or centering element 42 and a further metal bar, piece or rod 46 is centrally cast therein with the ends thereof protruding laterally from the locator or centering element 42. The two bars, pieces or rods 44, 46 are preferably made of mild steel and are tack welded to form a good electrical connection with each other and with the anodic locator or centering element 42 thereby serving to eliminate the possibility of corrosion taking place in the middle zone of the anodic locator or centering element 42 and leaving a piece of isolate zinc at each end.

The anodic locator or centering element 42 is mounted in plate 18 with the protruding ends of the bar, piece or rod 46 resting in the groove 34 and secured therein as, for example, by a welding process, with any slag and protruding metal being removed so that the outer planar surface 22 of the base plate 18 is planar to permit a good joint to be made with the other, facing base plate 16.

With this arrangement the anodic locator or centering element 42 provides a means for quick alignment of adjacent pile sections 16, 18 prior to interconnecting and securing the joint or coupling elements by means of the locking pins 28. With the pile in situ after being driven into the ground the anodic locator or centering element 42 which is electrically connected with the metal of the interconnected joint or coupling elements and the locking pins by means of the bars, pieces or rods 44, 46 will, in the presence of moisture in the ground surrounding the pile or a liquid media in which the pile is immersed and which acts as

an electrolyte, complete a galvanic circuit with the anodic locator or centering element 42 functioning as a sacrificial anode protecting the cathodic metal joint or coupling elements and associated locking pins from corrosion.

Whilst in the foregoing reference has been made, by way of example, to an embodiment of the invention wherein the protection element i.e. the sacrificial anode is constituted by and also functions as the locator or centering element it will be appreciated that other arrangements are possible and within the scope of this invention. Thus it will be appreciated that the protective element may be protected other than centrally of the pile connecting device; for example it may be incorporated as one or more inserts of a suitable metal such as zinc, magnesium or aluminium with the insert being disposed eccentrically or, in the case of more than one insert, in a uniform or random pattern in one or each of the plates constituting part of the pile connecting device or mounted thereon, the critical requirements being that a good electrical connection is made between the protective member or members and the metal of the pile connecting device. Also of course it will be appreciated that the protective member(s) or insert(s) may be of any desirable configuration and are confined to the generally barrel-shaped configuration of the protective member i.e. the locator or centering member 42 of the embodiment shown, by way of example, in the drawings.

Thus it will be apparent that a practical and economical pile joint is provided which incorporates a cathodic protection system utilizing as the sacrificial anode therein a locator or centering element which also functions as a means of aligning adjacent sections of the modular piling system prior to inter-connection of adjacent pile sections and driving of the pile.

WHAT WE CLAIM IS:

1. A pile connecting device, comprising two plates each plate being adapted to be secured to the end of a pile section, each plate having several corners and having a number of recesses extending inwardly from its periphery, there being a recess formed at a selected number of the corners of each plate, each plate having two parallel planar surfaces, one of which is adapted to bear against one of the planar surfaces of the other plate when the plates are brought into abutment, a recess in one plate registering with a corresponding recess in the other plate, and a locking pin adapted to be inserted and retained in a pair of registering recesses, said pin effective to interconnect said plates with said bearing surfaces in abutment, characterised by a protective member electrically connected to at least

one of said plates, said protective member serving to align said abutting plates and being made of a metal which exhibits a higher solution potential than the metal of said pile connecting device whereby when said pile connecting device is driven into damp ground or immersed in a liquid the protective member constitutes the sacrificial anode of a galvanic circuit, in which the pile connecting device constitutes the cathode and moisture in the ground or the liquid in which the pile connecting device is immersed constitutes the electrolyte, thereby protecting the pile connecting device from corrosion.

2. A pile connecting device as claimed in claim 1 wherein said protective member comprises a locator or centering element adapted to be positioned centrally of each of said plates when said plates are abutted and interconnected.

3. A pile connecting device as claimed in claim 1 made of steel.

4. A pile connecting device as claimed in claim 1, 2 or 3 wherein said protective member is made of zinc.

5. A pile connecting device as claimed in claim 1, 2 or 3 wherein said protective member is made of magnesium.

6. A pile connecting device as claimed in claim 1, 2 or 3 wherein said protective member is made of aluminium.

7. A pile connecting device as claimed in any of the preceding claims wherein said protective member is adapted to be positioned centrally of each of said plates with opposite end portions of said element extending into central apertures formed in each of said plates.

8. A pile connecting device as claimed in claim 7 wherein said protective member is provided with connecting members which extend in mutually normal directions symmetrically thereof.

9. A pile connecting device as claimed in claim 8 wherein one of said connecting members extends medially of and laterally from said protective member on opposite sides of the longitudinal axis thereof.

10. A pile connecting device as claimed in claim 9 wherein the protruding end portions of said one connecting member are adapted to be accommodated in one of a pair of mutually perpendicular grooves formed in one of said plates and which bisect the angles between the diagonals interconnecting opposed pairs of said locking-pin receiving recesses.

11. A pile connecting device as claimed in claim 9 wherein said protruding end portions of said one connecting member are electrically connected to said one plate.

12. A pile connecting device as claimed in any one of claims 8 to 11 wherein said connecting members are made of the same

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an electrolyte, complete a galvanic circuit with the anodic locator or centering element 42 functioning as a sacrificial anode protecting the cathodic metal joint or coupling elements and associated locking pins from corrosion.

Whilst in the foregoing reference has been made, by way of example, to an embodiment of the invention wherein the protection element i.e. the sacrificial anode is constituted by and also functions as the locator or centering element it will be appreciated that other arrangements are possible and within the scope of this invention. Thus it will be appreciated that the protective element may be protected other than centrally of the pile connecting device; for example it may be incorporated as one or more inserts of a suitable metal such as zinc, magnesium or aluminium with the insert being disposed eccentrically or, in the case of more than one insert, in a uniform or random pattern in one or each of the plates constituting part of the pile connecting device or mounted thereon, the critical requirements being that a good electrical connection is made between the protective member or members and the metal of the pile connecting device. Also of course it will be appreciated that the protective member(s) or insert(s) may be of any desirable configuration and are confined to the generally barrel-shaped configuration of the protective member i.e. the locator or centering member 42 of the embodiment shown, by way of example, in the drawings.

Thus it will be apparent that a practical and economical pile joint is provided which incorporates a cathodic protection system utilizing as the sacrificial anode therein a locator or centering element which also functions as a means of aligning adjacent sections of the modular piling system prior to inter-connection of adjacent pile sections and driving of the pile.

WHAT WE CLAIM IS:

1. A pile connecting device, comprising two plates each plate being adapted to be secured to the end of a pile section, each plate having several corners and having a number of recesses extending inwardly from its periphery, there being a recess formed at a selected number of the corners of each plate, each plate having two parallel planar surfaces, one of which is adapted to bear against one of the planar surfaces of the other plate when the plates are brought into abutment, a recess in one plate registering with a corresponding recess in the other plate, and a locking pin adapted to be inserted and retained in a pair of registering recesses, said pin effective to interconnect said plates with said bearing surfaces in abutment, characterised by a protective member electrically connected to at least

one of said plates, said protective member serving to align said abutting plates and being made of a metal which exhibits a higher solution potential than the metal of said pile connecting device whereby when said pile connecting device is driven into damp ground or immersed in a liquid the protective member constitutes the sacrificial anode of a galvanic circuit, in which the pile connecting device constitutes the cathode and moisture in the ground or the liquid in which the pile connecting device is immersed constitutes the electrolyte, thereby protecting the pile connecting device from corrosion.

2. A pile connecting device as claimed in claim 1 wherein said protective member comprises a locator or centering element adapted to be positioned centrally of each of said plates when said plates are abutted and interconnected.

3. A pile connecting device as claimed in claim 1 made of steel.

4. A pile connecting device as claimed in claim 1, 2 or 3 wherein said protective member is made of zinc.

5. A pile connecting device as claimed in claim 1, 2 or 3 wherein said protective member is made of magnesium.

6. A pile connecting device as claimed in claim 1, 2 or 3 wherein said protective member is made of aluminium.

7. A pile connecting device as claimed in any of the preceding claims wherein said protective member is adapted to be positioned centrally of each of said plates with opposite end portions of said element extending into central apertures formed in each of said plates.

8. A pile connecting device as claimed in claim 7 wherein said protective member is provided with connecting members which extend in mutually normal directions symmetrically thereof.

9. A pile connecting device as claimed in claim 8 wherein one of said connecting members extends medially of and laterally from said protective member on opposite sides of the longitudinal axis thereof.

10. A pile connecting device as claimed in claim 9 wherein the protruding end portions of said one connecting member are adapted to be accommodated in one of a pair of mutually perpendicular grooves formed in one of said plates and which bisect the angles between the diagonals interconnecting opposed pairs of said locking-pin receiving recesses.

11. A pile connecting device as claimed in claim 9 wherein said protruding end portions of said one connecting member are electrically connected to said one plate.

12. A pile connecting device as claimed in any one of claims 8 to 11 wherein said connecting members are made of the same

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metal as that of the pile connecting device.

13. A method of protecting metallic pile connecting devices used for interconnecting adjacent sections of a modular piling system, comprising the steps of associating with each of said devices a protective member and effecting a positive connection between said protective member and the metal of said pile connecting device whereby to provide a continuous electrically conductive path between said protective element and said metal, said protective member being formed of a metal having a solution potential greater than that of the metal of which the pile connecting device is made, whereby the protective member will function as a sacrificial anode in a galvanic circuit completed when said pile connecting device is buried in damp ground or immersed in a liquid either of which acts as an electrolyte, and thus protect the metal of the pile connecting device against corrosion.

14. A method as claimed in claim 13 wherein the protective member comprises a locator or centering element adapted to be positioned centrally of each of a pair of plates forming part of the pile connecting device when said plates are abutted when the pile sections are connected prior to driving thereof.

15. A method as claimed in claim 14 wherein said pile connecting device is made of steel and said protective member is made of zinc.

16. A method as claimed in claim 14 wherein said pile connecting device is made of steel and said protective member is made of magnesium.

17. A method as claimed in claim 14 wherein said pile connecting device is made of steel and said protective member is made of aluminium.

18. A method as claimed in any one of claims 14 to 17 wherein said protective member is positioned centrally of each of said plates with opposite end portions of said protective member extending into central apertures formed in each of said plates.

19. A method as claimed in claim 18 wherein said protective member is provided with connecting elements which extend in mutually normal directions symmetrically thereof.

20. A method as claimed in claim 19 wherein one of said connecting elements extends medially of and laterally from said protective member on opposite sides of the longitudinal axis thereof.

21. A method as claimed in claim 20 wherein the protruding end portions of said one connecting element are adapted to be accommodated in one of a pair of mutually perpendicular grooves formed in one of said plates and which bisect the angles between the diagonals interconnecting opposed pairs

of recesses formed at a selected number of the corners of each of said plates.

22. A method as claimed in claim 21 wherein said protruding end portions are electrically connected to said one plate.

23. A method as claimed in any one of claims 19 to 22 wherein said connecting elements are made of the same metal as that of the pile connecting device.

24. A pile connecting device constructed, adapted and arranged to operate substantially as described herein with reference to the accompanying drawings.

25. A method of protecting metal pile connecting devices substantially as described herein with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1980.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.