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(60) Derived from Application No **29664/78** Under Section **15(4)** of the Patents Act **1977**
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(54) Method of Grouting an Annular Passage

(57) A method of grouting an annular passage includes sealing the annular passage at a first location, injecting gas into the passage to purge it of material, sealing the passage at a second location, venting the sealed passageway and injecting grouting material therein. Air is the preferred gas and the passage is preferably vented to atmospheric pressure. The preferred means of sealing the passage is by use of inflatable packers 40. The method is particularly useful for grouting the annular passage between a tubular oil rig leg and a pile driven therethrough.

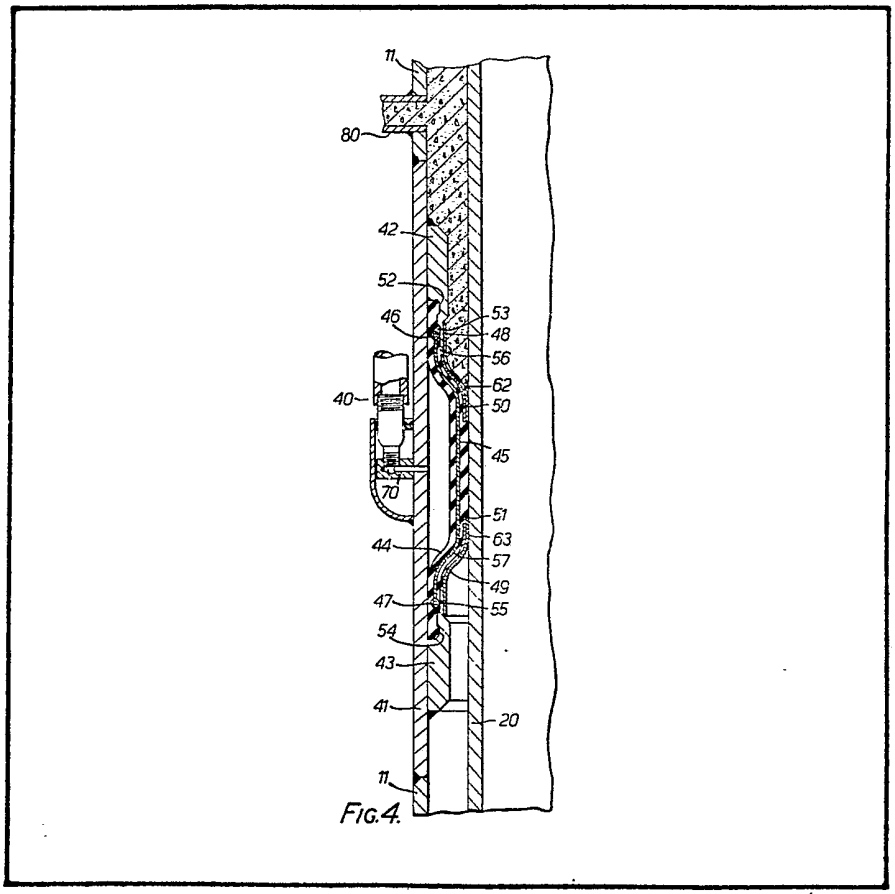

FIG.4.

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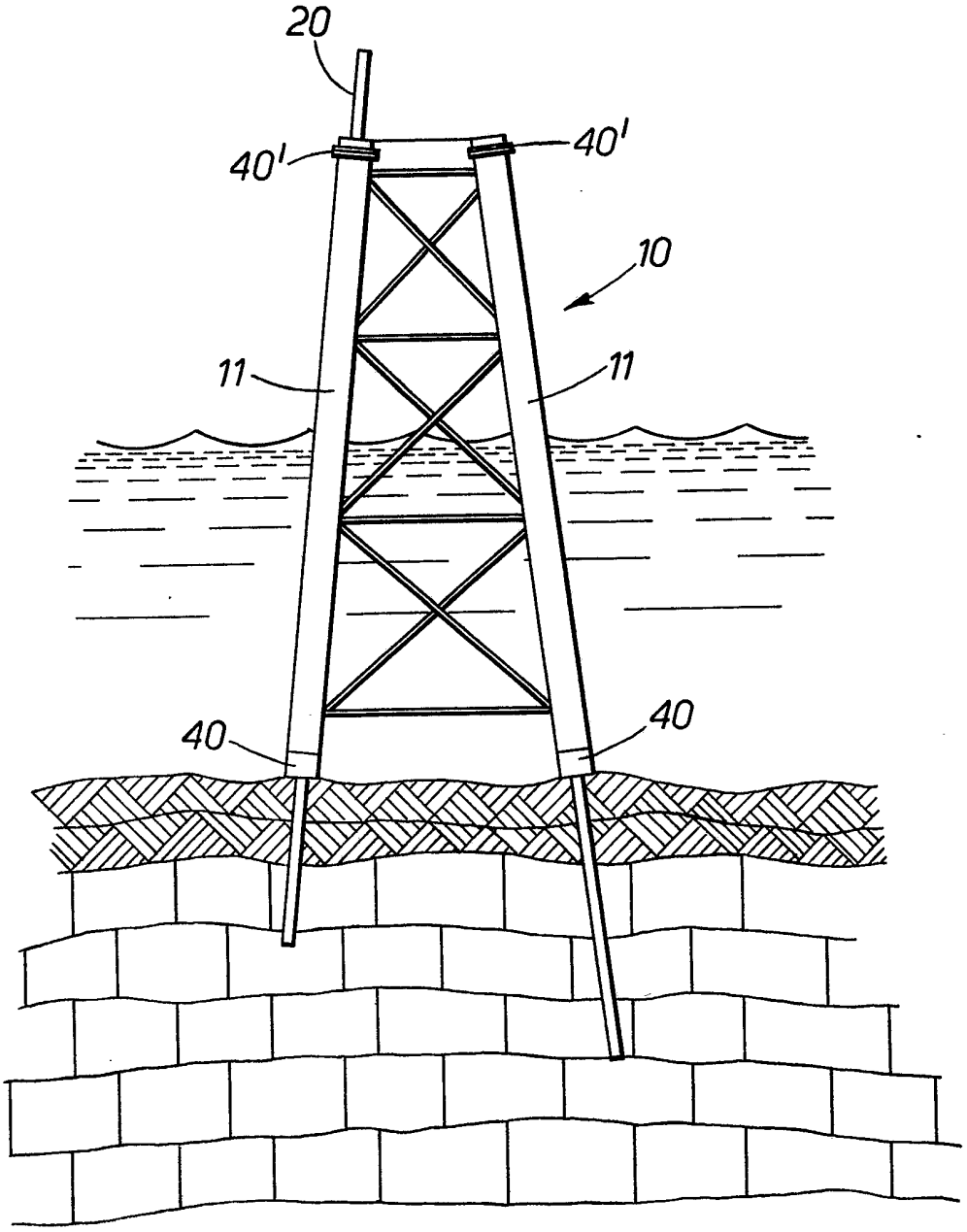

FIG.1.

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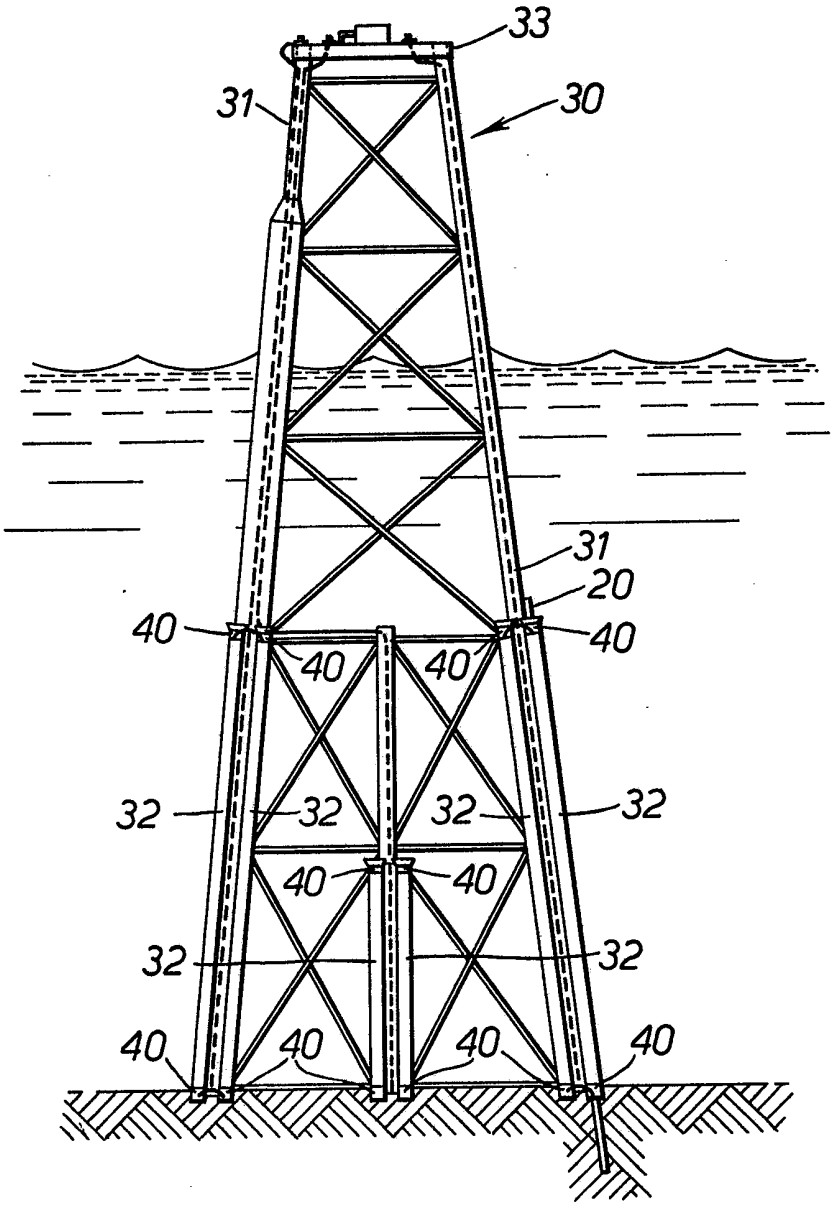

FIG.2.

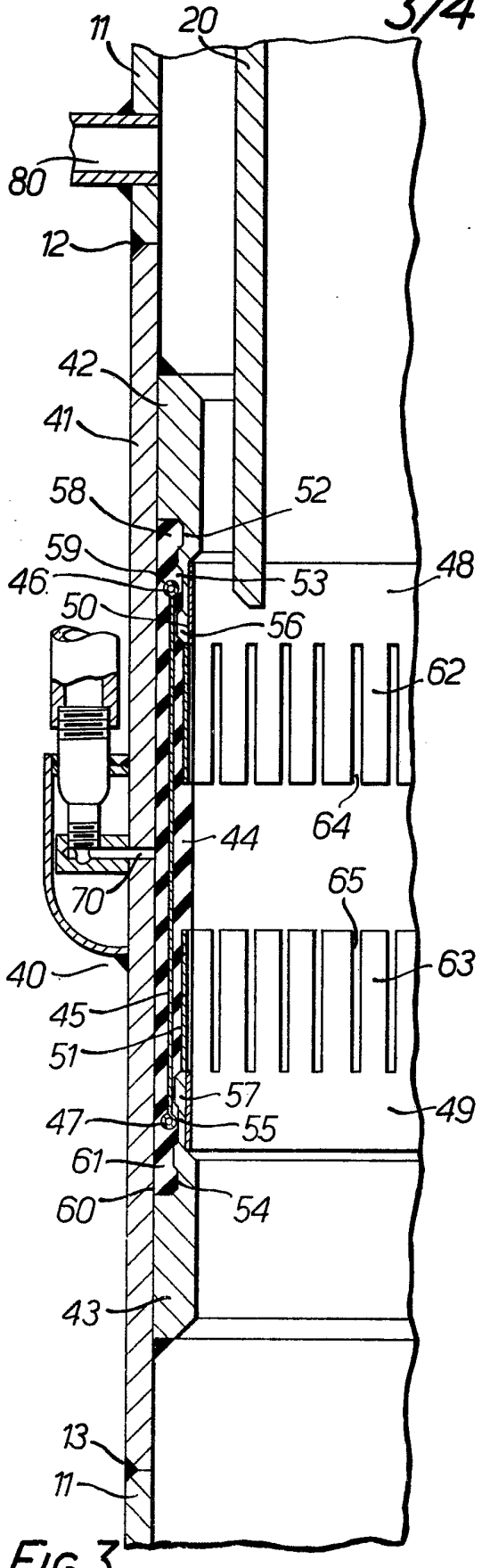
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FIG. 3.

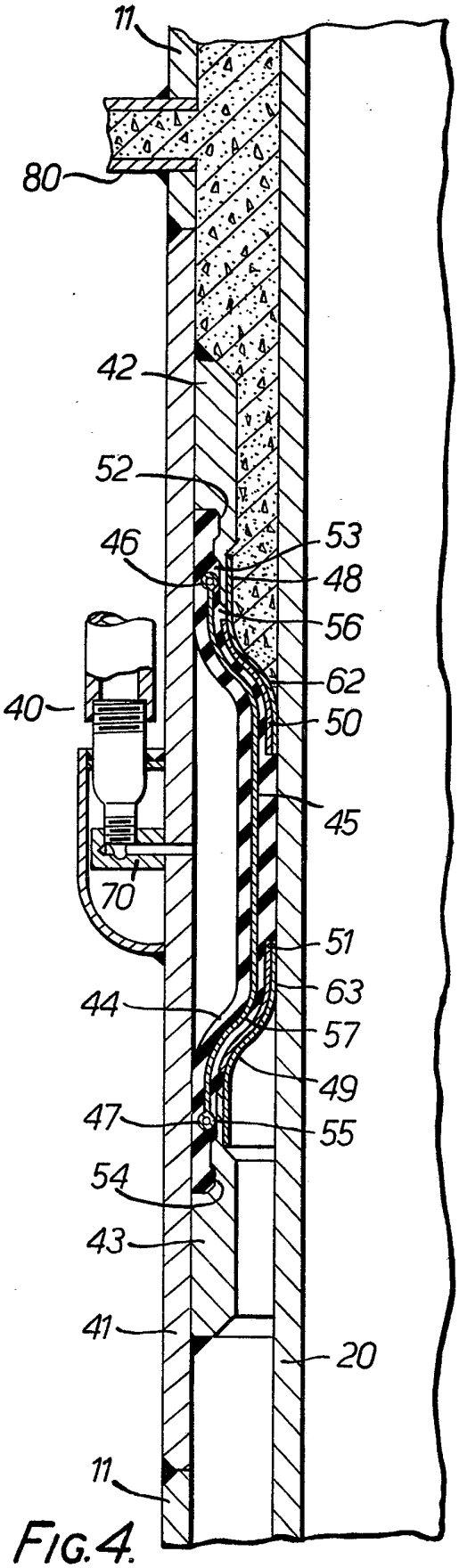
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FIG. 4.

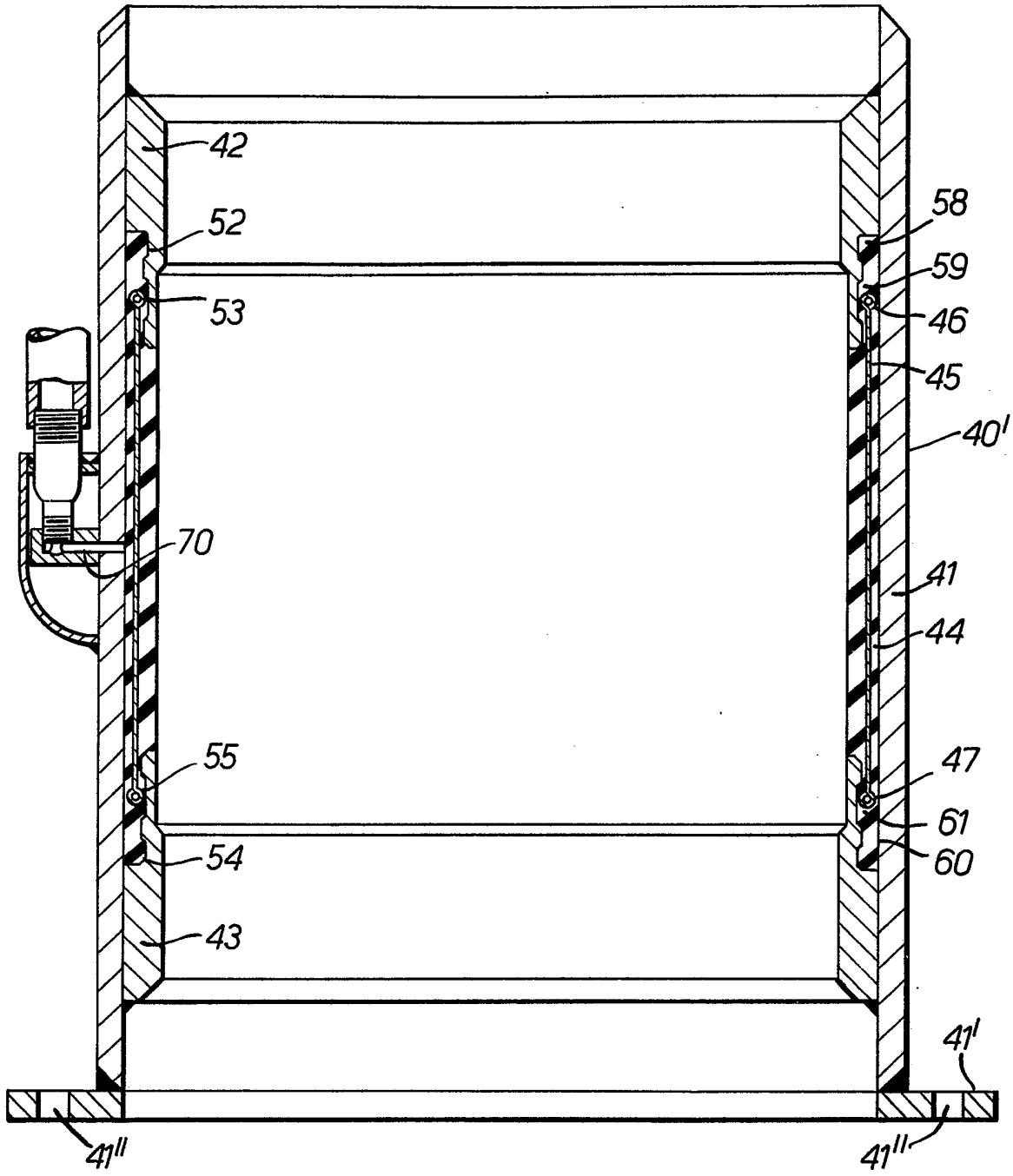

FIG. 5.

SPECIFICATION

Method of Grouting an Annular Passage

This invention relates to a method of grouting an annular passage formed between a first annular member and a concentric second annular member, e.g. between a pile and a pile sleeve or jacket leg of an offshore oil rig.

According to the present invention, there is provided a method of grouting an annular passage formed between a first annular member and a concentric second annular member, over a length from a first to a second location, which comprises the steps of: sealing said passage at said first location; injecting a gas into said passage to expel material from within said passage between said first and second locations; sealing said passage at the second location while maintaining said length free of material; venting said passage between the first and the second locations while maintaining said length free of material; and injecting grouting material into said passage between the first location and second locations.

Preferably, inflatable packers are used to seal said passage at the first and second locations. Certain inflatable packers particularly useful in the method of this invention are described and claimed in our U.K. Patent Application No. 29664/78 (Serial No. 2,003,963) to which reference should be made for further details.

The gas used to flush solids and liquids materials from the passage prior to grouting is preferably air, and the passage is preferably vented to substantially atmospheric pressure prior to grouting.

One preferred embodiment of the invention consists in a method of grouting an annular passage formed between a pile driven in a jacket leg of an offshore platform *in situ,* the grouting being effected over a length between a first and a second location, which comprises: installing an inflatable packer at a first location in said passage; installing an inflatable packer at a second location in said passage; sealing said passage at the first location by inflating said inflatable packer; injecting a gas into said passage between said inflatable packer at the first location and said inflatable packer at the second location to expel any material contained within said length of annulus; sealing said passage at the second location by inflating said inflatable packer while maintaining said length free of material; venting said passage between the first and second locations while maintaining said length free of material; and injecting grouting material into said passage between the first location and the second location.

In order that the invention may be more fully understood, embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 shows inflatable packers installed in the jacket legs of an offshore platform for grouting purposes;

Figure 2 shows inflatable packers installed in the pile sleeves of the jacket legs of an offshore platform, for grouting purposes;

Figure 3 shows a packer in partial cross-section installed in a jacket leg or pile sleeve in an uninflated position;

Figure 4 shows a packer in partial cross-section installed in a jacket leg or pile sleeve in an inflated position with grout filling the annulus between the pile and the jacket leg; and

Figure 5 is a modified packer for use as the top packer in a jacket leg.

Referring to Figure 1, an offshore platform 10 is shown having inflatable packers 40 installed in the bottom of the platform jacket legs 11 while the inflatable packers 40′ are installed in the top of the platform jacket legs 11. A pile 20 is shown as being partially driven to depth with the pile extending out of the top of the inflatable packer 40′ while another pile 20 is shown being driven the desired depth.

In Figure 2, an offshore platform 30 is shown having the inflatable packers 40 installed in the top and bottom of the pile sleeves 32 of the jacket legs 31. A pile 20 is shown as being driven to depth.

As shown in Figure 3, the inflatable packer 40 comprises a packer housing 41, guide rings 42 and 43, an elastomeric packer member 44 and packer member back-up shoes 48 and 49. The packer housing 41 is cylindrical and made in any convenient diameter to match the jacket leg 11 to which it is welded as at 12 and 13.

The guide ring 42 is welded to the packer housing 41 to secure one end of the packer member 44 within the packer housing 41 from any axial movement within the packer housing 41. The guide ring 42 is formed with a reduced thickness portion having two annular channels 52 and 53 which mate with the annular beads 58 and 59 respectively on one end of the packer member 44. The guide ring 42 further includes annular bead 56 which prevents the withdrawal of annular bead 59 of packer member 44 from annular channel 53.

Similarly, guide ring 43 is welded to the packer housing 41 to secure the other end of the packer member 44 within the packer housing 41 from any axial movement within the packer housing 41. The guide ring 43 is formed with a reduced thickness portion having two annular channels 54 and 55 which mate with annular beads 60 and 61 respectively on the other end of packer member 44. The guide ring 43 further includes annular bead 57 which prevents the withdrawal of annular bead 61 of packer member 44 from annular channel 55.

The packer member 44 can be formed of any suitable elastomeric material, although rubber is preferred. The packer member 44 has an annular reinforcing member 45 which is anchored about one end by an annular metal ring 46 contained in annular bead 59 located on one end of the packer member 44 while the other end of reinforcing member 45 is anchored about annular metal ring

47 contained in annular bead 61 located on the other end of the packer member 44. The reinforcing member 45 can be of any suitable material, although a fabric of nylon or Kevlar is preferred. The annular metal rings 46 and 47 may be either solid steel or twisted steel cable. The packer member 44 further comprises an annular band of material 50 located adjacent one end of the packer member 44 on the inner diameter thereof which underlies the fingers 62 of back-up shoe 48 while an annular band of material 51 located adjacent the other end of the packer member 44 on the inner diameter thereof underlies the fingers 63 of back-up shoe 49. The annular bands 50 and 51 of the material serve to protect the packer member 44 from damage by the fingers 62 and 63 of the back-up shoes 48 and 49 respectively when the packer element is being inflated and to prevent the flow of rubber into the slots 64 and 65 when the packer member 44 is being formed. The annular bands 50 and 51 may be formed of any suitable flexible material which has sufficient strength to protect packer member 44, such as steel, brass, etc., although a fabric of nylon or Kevlar is preferred.

The back-up shoe 48 is an annular metal band having fingers 62 separated by spaces 64 and is located on the inner diameter of the packer member 44 adjacent one end thereof. Similarly, the back-up shoe 49 is an annular metal band having fingers 63 separated by spaces 65 and is located on the inner diameter of the packer member 44 adjacent the other end thereof. The back-up shoes 48 and 49 may be formed of any suitable metal, although steel is preferred. The back-up shoes 48 and 49 initially protect the packer element 44 from being damaged by the pile 20 while the pile is being driven therethrough since the back-up shoes 48 and 49 hold the packer member 44 against the packer housing 41 until the packer member 44 is inflated.

Referring to Figure 4, the inflatable packer 40 is shown in its inflated position. The packer member 44 is inflated to firmly grip the pile 20, which has been driven to the desired depth, by pumping any suitable fluid or gas under pressure through the packer inflation port 70. As shown, when the packer member 44 is inflated, the back-up shoes 48 and 49 are deflected inwardly until the fingers 62 and 63 are seated on the pile 20. When the packer member 44 is in its inflated position, the back-up shoes 48 and 49 lend axial support to the packer member 44 and prevent axial extrusion and subsequent damage of the packer member 44 over annular beads 56 and 57 of guide rings 42 and 43 respectively. As further shown, when the packer member 44 is inflated, the ends of the packer member 44 are secured from axial movement by means of annular rings 46 and 47. The annular metal rings 46 and 47 prevent the ends of packer member 44 from being forced from the annular channels 52 and 53 of the guide ring 42 and annular channels 54 and 55 of guide ring 43 respectively since the annular metal rings 46 and 47 prevent the compression of the ends of the packer member 44 to a degree which would allow the ends of the packer member 44 to pass between the annular beads 56 and 57 and the packer housing 41.

The ends of the packer member 44 may be secured against axial movement within the packer housing 41 by the guide rings 42 and 43 since the inflation of the packer member 44 occurs inwardly thereby effectively compressing the packer member 44.

After the packer member 44 has been inflated, grouting material is pumped through the grouting line 80 into the annulus between the pile 20 and the platform jacket leg 11 above the packer 40 with the packer supporting the weight of the grouting in the annulus while preventing the grouting from leaking into the annulus below the packer 40 or the surrounding environment from leaking into the annulus above the packer 40 and containinating the grouting material.

Referring to Figure 5, a modified inflatable packer 40′ is shown. The inflatable packer 40′ is designed for use as the top packer in the platform jacket legs 11 during a grouting operation. The inflatable packer 40′ is identical to the packer 40 described hereinbefore, except it does not have back-up shoes and annular bands of material underlying the back-up shoes for the packer member 44 and it has a flange 41′ located on one end of the packer housing 41.

Since the packer 40′ is used as a temporary seal on the top of the platform jacket legs 11 during a grouting operation, no large axial forces due to the weight of the grouting material act upon the packet member 44. Therefore, it is undesirable to have the back-up shoes in the packer 40′ since once the packer has been inflated, they would remain in engagement with the pile and prevent removal of the packer 40′ from the platform jacket leg after the grouting operation is completed. The flange 41′ on one end of packer housing is formed with a series of holes 41″ through which threaded fasteners may be inserted to secure the packer 40′ to the top of jacket leg 11. Although the use of a flange and threaded fasteners is the preferred means for temporarily securing the packer 40′ to the top of jacket leg 11, any suitable attachment means may be used, such as welding.

Although annular bands of material have not been shown which would underlie the back-up shoes since the packer 40′ does not require back-up shoes, the packer element 44 could be formed with the annular bands if so desired.

Referring to Figure 1, the inflatable packers 40 and 40′ are shown installed on the lower ends and top ends respectively of platform jacket legs 11. As shown, the packers 40 are welded to the bottoms of jacket legs 11, while the packers 40′ are secured by means of suitable threaded fasteners to the tops of jacket legs 11. Although not shown in the drawing, inflation lines run to the inflation ports 70 of each packer 40 and 40′ while grouting lines typically run to the jacket legs 11 immediately below the packers 40′.

To grout the annulus between the piles 20 and the jacket legs 11 after the piles have been driven to depth, the packers 40′ on the tops of platform jacket legs 11 are inflated to seal the annuli between the piles and the jacket legs. Air or any other suitable gas is then injected through the grout lines to empty the annuli between the piles and jacket legs by forcing the water in the annuli out the bottoms of the jacket legs past the packers 40. When the annuli are empty, the packers 40 are inflated to seal the annuli at the bottom of the jacket legs. The air pressure within the annuli is then released to substantially atmospheric pressure, although the air pressure may be released to any desired pressure level, and the packers 40′ may be removed from the tops of the jacket legs 11 if so desired. At this time, grout is pumped through the grouting lines into the annuli and falls to the bottom of the annuli until the annuli are completely filled. If the packers 40′ have not been removed, they are removed for future use at this time.

If the platform 10 has grouting lines running to the bottoms of the annuli between the piles 20 and the jacket legs 11 rather than the tops of the annuli, the method of grouting remains unchanged.

By using a packer at both the top and bottom of the jacket legs 11 on the platform 10, an improved grouting method results because it is not necessary to maintain the annuli in the jacket legs under pressure until the grout hardens to ensure the water surrounding the jacket legs does not dilute the grouting material, it can be readily ascertained whether or not the annuli are free of water to insure no dilution of the grouting material and it is not necessary to pump large quantities of grouting material into the silt on the ocean floor surrounding the jacket legs to insure that the annuli in the jacket legs have been filled with grouting material.

Referring to Figure 2, the platform 30 is shown having packers 40 installed in the tops and bottoms of pile sleeves 32 of platform jacket legs 31 and the pile sleeves 32 intermediate the jacket legs 31. Although the packer inflation lines are shown in phantom in Figure 2, the pile sleeve grouting lines which are typically installed in the annuli adjacent the bottom packers 40 in the pile sleeves 32 and the pile sleeve vent lines which are typically installed adjacent the top packers 40 in the pile sleeves 32 are not shown. After the piles 20 are driven to the desired depths, the packers 40 in the tops of the pile sleeves 32 are inflated to seal the annuli between the piles 20 and the pile sleeves 32. The annuli are then evacuated by injecting air or any suitable gas into the vent lines to force the water in the annuli out the bottoms of the pile sleeves 32 past the packers 40. Subsequently, the packers 40 in the bottoms of pile sleeves 32 are inflated to seal the bottoms of the annuli from the surrounding environment. The air pressure in the annuli is then released to any desired pressure level, although atmospheric pressure is the normal venting pressure and grouting is pumped through the grouting lines adjacent the bottom packers 40 in the pile sleeves 32 until the grouting flows out the vent lines at the surface 33 of the platform 30. If an amount of water remained in the annuli and diluted the grouting material being pumped into the annuli, grouting can be pumped into the annuli until such time as the grouting flowing out the vent lines at the platform surface 33 is the same quality as the grouting being pumped into the annuli.

By using a packer at both the top and bottom of the pile sleeves 32 on the platform 30, an improved grouting method results because it is not necessary to maintain the annuli in the pile sleeves under pressure until the grout hardens to ensure the water surrounding the pile sleeves does not dilute the grouting material, it can be readily ascertained whether or not the annuli are free of water to insure no dilution of the grouting material and it is not necessary to pump large quantities of grouting material into the silt on the ocean floor surrounding the jacket legs to ensure that the annuli in the jacket legs have been filled with grouting material.

Although the method of grouting has been particularly described for use in platform jacket leg and pile sleeve grouting operations, it may be used in any situation where grouting is desired between two members with an annular passage therebetween.

Claims

1. A method of grouting an annular passage formed between a first annular member and a concentric second annular member, over a length from a first to a second location, which comprises the steps of: sealing said passage at said first location; injecting a gas into said passage to expel material from within said passage between said first and second locations; sealing said passage at the second location while maintaining said length free of material; venting said passage between the first and second locations while maintaining said length free of material; and injecting grouting material into said passage between the first location and second locations.

2. A method according to Claim 1 wherein inflatable packers are used to seal said passage at the first and second locations.

3. A method according to Claim 1 or 2 wherein the gas injected into said passage comprises air.

4. A method according to Claim 1, 2 or 3, wherein the said venting of the passage is effected to substantially atmospheric pressure.

5. A method according to Claims 2 and 4 wherein the inflatable packer is removed from the first location after venting but before injecting said grouting material.

6. A method according to Claim 2, wherein said inflatable packer is removed from the first location after injecting grouting material.

7. A method according to any of Claims 1 to 6, wherein the annular passage is formed by a pile

driven in a jacket leg or pile sleeve of an offshore platform.

8. A method of grouting an annular passage formed between a pile driven in a jacket leg of an offshore platform *in situ,* the grouting being effected over a length between a first and second location, which comprises: installing an inflatable packer at a first location in said passage; installing an inflatable packer at a second location in said passage; sealing said passage at the first location by inflating said inflatable packer; injecting a gas into said passage between said inflatable packer at the first location and said inflatable packer at the second location to expel any material contained within said length of annulus; sealing said passage at the second location by inflating said inflatable packer while maintaining said length free of material; venting said passage between the first and second locations while maintaining said length free of material; and injecting grouting material into said passage between the first location and the second location.

9. A method according to Claim 8, further comprising the step of: removing said inflatable packer from the first location before injecting said grouting material into said annulus.

10. A method according to Claim 8 further comprising the step of: removing said inflatable packer from the first location in said annulus after said grouting.

11. A method according to Claim 8, 9 or 10, wherein said inflatable packer installed at the first location in said passage is installed at the top of the jacket leg and said inflatable packer installed at the second location in said passage is installed at the bottom of the jacket leg.

12. A method according to Claim 8, 9, 10 or 11 wherein said gas is air.

13. A method according to Claim 8 wherein the venting of said annulus is effected to substantially atmospheric pressure.

14. A method according to Claim 2 or Claim 8 wherein the or each inflatable packer is one claimed in our Application No. 29664/78, (Serial No. 2,003,963).

15. A method of grouting an annulus between a first annular member and a concentric second annular member, substantially as herein described with reference to Figures 3 and 4 of the accompanying drawings.

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