March 16, 1971 E. B. THAXTON 3,570,259

ANNULUS SEAL AND PILE WIPER

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FIG. 1

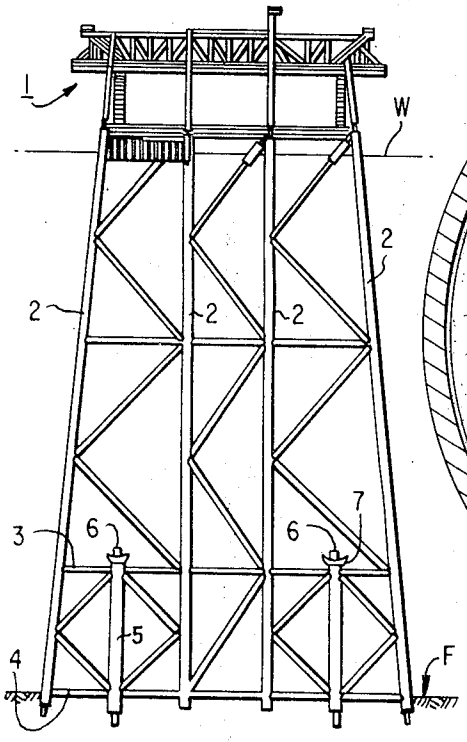


FIG. 3

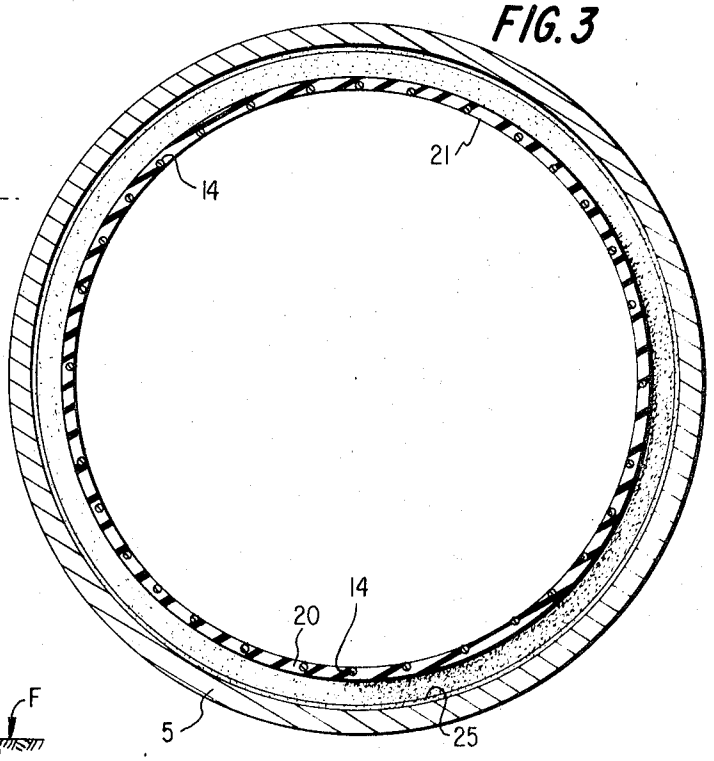
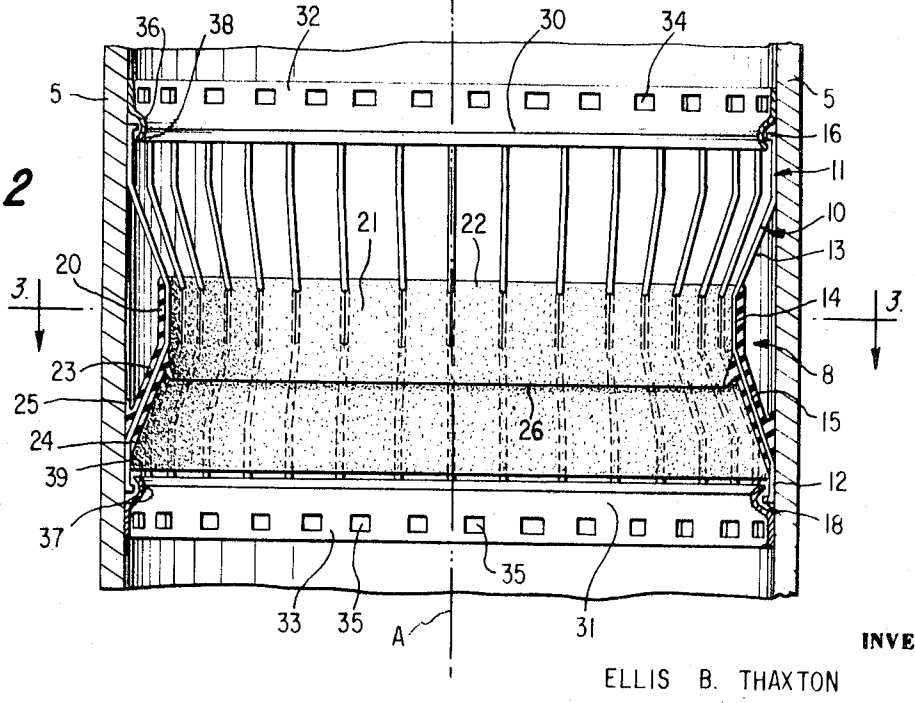


FIG. 2



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FIG. 5

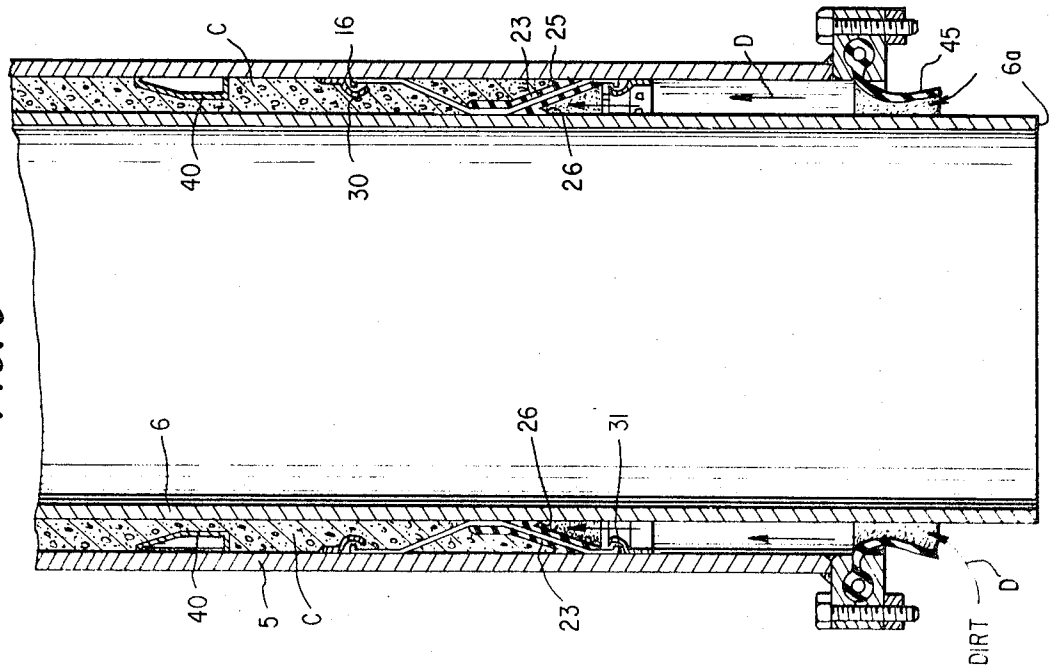
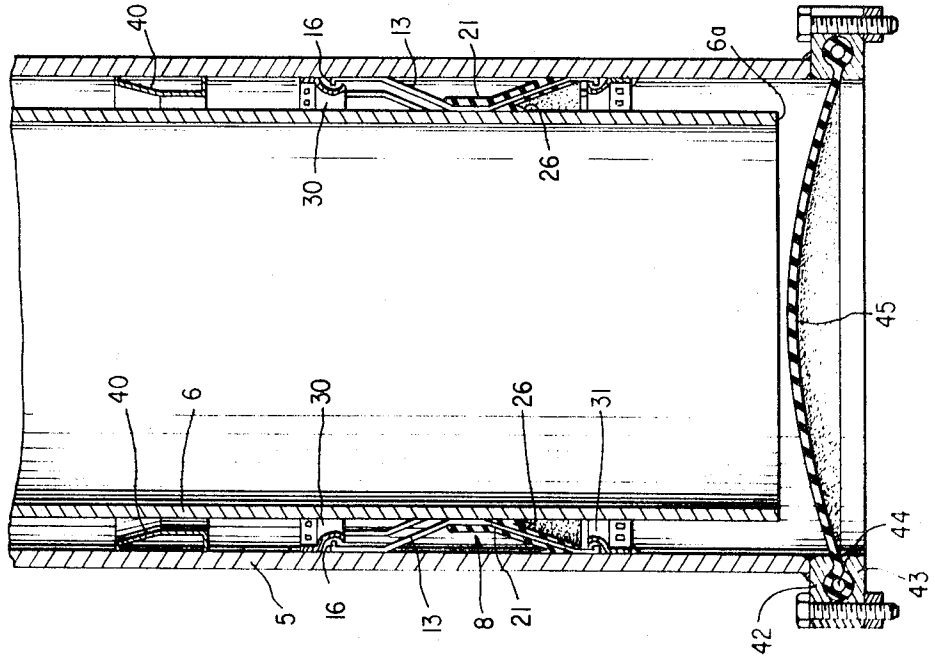


FIG. 4



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ANNULUS SEAL AND PILE WIPER

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ABSTRACT OF THE DISCLOSURE

A seal for sealing the annulus between a pile and a hollow tubular member such as a platform leg or a skirt guide through which it extends, the hollow members being located, for instance, at the bottom of a marine drilling platform secured by means of piles to the floor of the sea, and the annulus between each hollow member and pile through it being poured full of cement above the seal when the platform has been moved into place and the piles have been driven.

This invention relates to a novel annular seal of the type which is secured to the lower inside surface of a hollow skirt guide or platform leg member of large diameter through which a large steel pile is driven, for example, for the purpose of securing the platform structure to the bottom of the sea. When the piles are driven, the seal closes the annulus between the pile and the hollow member at a location near the bottom of the latter to support a column of cement which is then poured thereinto while it hardens. The cement column is often quite high, typically enghty feet or more, and therefore the weight supported by the seal during hardening very great.

It is a principal object of this invention to provide a rugged and highly reliable seal to be fixed to and supported by the inner surface of a large diameter hollow platform support member, and to provide a seal which can be manufactured and installed economically in view of the fact that it is used only once.

It is a major object of the invention to provide a seal of the character described which is operative to prevent the flow of liquids or entrained solids through the annulus between a pile and a platform leg or skirt guide in either direction, up or down. While the pile is being driven the seal must resist entry of silt and debris into the annulus from below. However, later on, the same seal must support cement poured into the annulus from above while the cement hardens. Thus the seal must be able to function bidirectionally without requiring any form of local manipulation thereof.

Another object of the invention is to provide a bidirectional annulus seal which can function cooperatively with a rupturable diaphragm closure of the type which is used to close the lower end of a skirt guide or a hollow platform leg while lowering the platform assembly at a drilling site. In this type of operation when the platform assembly has been positioned at the site, the piles are driven through the seals to rupture the diaphragms and enter the bottom of the sea therethrough. The present novel seal cooperates with and augments the diaphragm at the time of rupturing of the latter by sealing the annulus against a sudden inrush of debris and mud entrained in water which would otherwise fill the annulus through the broken diaphragm.

A further object of the invention is to provide a seal through which a pile can be driven while maintaining the efficacy of the seal despite radial eccentricities of the pile within the hollow platform member.

Another important object of the invention is to provide a platform leg or skirt guide and seal assembly of the type described having means for protecting resilient parts of the seal from physical damage while a pile is being inserted and driven through it into the floor of the sea.

A still further object of the invention is to provide means for anchoring the periphery of the seal to the inner surface of the hollow platform member in a way which will cause the end portions of the seal to lie flat thereagainst, and which will permit axial lengthening and foreshortening of the seal when it is distorted radially for instance by a pile passing therethrough.

Another important object of the invention is to provide anchor means for securing the seal to the inner surface of the hollow platform member to provide continuous annular support for the reinforcement wires of the seal both below and from above.

A further object of the invention is to provide a seal including an elastomeric body efficiently supported on flexible wires which serve both to support the body and to guide a pile therethrough in a manner which will prevent damage to the body.

Other objects and advantages of the invention will become apparent during the following discussion of the drawings, wherein:

FIG. 1 shows a typical marine drilling platform assembly having legs extending to the floor of the sea, and having a plurality of skirt guides secured thereto and surrounding piles driven into the bottom of the sea to anchor the platform thereto;

FIG. 2 is an enlarged longitudinal cross-section taken through the bottom of a platform leg or skirt guide and showing the seal installed therein, but with the pile removed;

FIG. 3 is a section view taken along line 3—3 of FIG. 2;

FIG. 4 is a longitudinal section view similar to FIG. 2 but augmented to show a pile entered into the seal and stopping just above a rupturable diaphragm; and

FIG. 5 is a view similar to FIG. 4 but showing the pile driven through the diaphragm and rupturing it, and showing cement filling the annulus above the seal which is excluding silt and debris from below.

Referring now to FIG. 1 this figure shows a drilling platform **1** supported on a plurality of legs **2** between which reinforcing truss work is provided including horizontal members **3** and **4**. These members also support skirt guides **5** which are disposed between the legs **2** of the platform assembly near the bottom thereof. The water level is shown at W in FIG. 1, and the floor of the ocean is designated by the letter F. The skirt guides **5** and the legs **2** extend somewhat below the floor level F and are embedded in the mud at the bottom of the sea, and are transfixed by piles **6** which are generally in the form of steel cylinders, for instance, about three or more feet in diameter. The piles **6** are introduced through upper flared tops **7** of the skirt guides **5**, and are driven as far as possible into the floor of the sea. When the pile driving operation has been completed the annulus between each pile and skirt guide is poured full of cement C which is then allowed to harden and thereby make a unitary structure of the piles **6** and the legs **2** and skirt guides **5** which surround them.

Each of the hollow platform members which houses a pile is provided at its lower end with a seal **8** which closes the space between the internal surface of the member and the outer surface of the pile **6** so that when the cement C is poured into the annulus above the seal **8** the cement will not escape through the lower end of the hollow member, but will be retained therein while it hardens.

The enlarged cross-section shown in FIG. 2 illustrates a seal **8** according to the present invention mounted on the inside surface of a hollow member comprising either a leg **2** or a skirt guide **5** and including an annular series of wire members **10** arranged in substantially vertical planes which are mutually spaced from each other in the circumferential direction. Each of the wires comprises an upper end portion **11**, a lower end portion **12** and a central portion comprising an upper length of wire **13** which tapers downwardly and radially inwardly to a center length **14** which is substantially vertical, and a lower length **15** which tapers downwardly and outwardly and joins the lower end portion **12**. Each of the wires has a hooked tip **16** at its upper end and a hooked tip **18** at its lower end for the purpose hereinafter explained.

The seal further includes an elastomeric body **20** including a central portion **21** at least coextensive with the center lengths **14** of the wires and ending in an outwardly flared upper lip **22** which graduates the upper end of the body **20** outwardly so that when a pile **6** is installed through the seal its lower end will not snag upon the upper end **22** of the elastomeric body, which might otherwise tear the body. As can be seen in FIG. 3, the center lengths **14** of the wires are embedded in the central portion **21** of the body in such a way that their inner surfaces are substantially tangent with the inner periphery of the elastomeric body.

The elastomeric body also includes a lower portion **23**, which completely embeds the lower lengths **15** of the central portions of the wires **10**, and at its lower end **24** extends into the area occupied by the lower end portions **12** of the wires and fills the space between them where they abut the sides of the leg **2** or skirt guide **5**. A lip **25** extends upwardly from the lower end portions **12** of the wires and seals tightly against the inner surface of the leg **2** or skirt guide **5** so as to prevent downward passage of liquids between the seal **8** and the inner surface of the former.

At the inner periphery of the elastomeric body there is a downwardly extending lip **26** which is normally curved radially inwardly toward the axis A and thereby ensures a tight seal against the piling and a resilient wiping action thereagainst. Note that the inner diameter of the seal in the vicinity of the center portion **21** thereof is made somewhat smaller than the outer diameter of the piling so that the piling, when driven through the seal, will cause the latter to expand somewhat. Likewise, the outer diameter of the seal in the vicinity of the lip **25** will be made somewhat larger than the inner diameter of the leg **2** or skirt guide **5** as to provide a tight fit therein involving a certain amount of compression of the elastomeric body in the vicinity of its lower end when installed.

The seal is longitudinally positioned and supported within the hollow platform member by captivating means at its upper and lower ends, these means taking the form of axially opposed and spaced rings **30** and **31**, the rings having welding rims **32** and **33** facing away from the wires **10** and having a number of holes **34** and **35** through which the rims **32** can be welded securely to the inner surface of the hollow member. The ring portions which face toward the wires **10** curve radially inwardly toward the centers of the rings as at **36** and **37**, and then curve radially outwardly again as at **38** and **39** to provide clearances for the upper and lower ends of the wires **10**, while at the same time captivating the hooked tips **16** and **18** between the ring and the sidewall of the leg **2** or skirt guide **5**, whereby the wire is free to move up and down through a limited distance within the captivating means but is prevented from withdrawal therefrom. As stated above the seal body is made so that its inner diameter is somewhat smaller when in relaxed condition than the outer diameter of a pile **6**, and therefore when the pile is driven through the seal the central portion **21** thereof must expand in order to receive the pile. Such expansion drives the central portions of the wires outwardly relative to the axis A and therefore somewhat elongates the distance between the hooked ends **16** and **18** of the wires. Thus, the captivating means allows a certain amount of axial lengthening and foreshortening of the wires during use of the seal and until the cement C sets within the annulus as shown in FIG. 5.

FIGS. 4 and 5 show the seal in use and sealing the annulus between the leg **2** or skirt guide **5** and the pile **6**. An annular series of deflectors **40** is provided to direct the lower end **6***a* of the piling radially inward as the piling is lowered toward the seal so that the pile does not catch upon the ring **30** and tear it from the inner surface of the hollow platform member. In an alternative embodiment, the deffectors can be made part of the upper ring **30**. The pile **6** then continues to travel downwardly until it contacts the wires somewhere in the vicinity of their downwardly and inwardly tapering lengths **13**. An annular cage of wires is formed by the series of wires **10** which then deflects the lower end of the pile toward the center of the seal and causes it to pass cleanly and non-destructively through the center portion **21** of the elastomeric body and downwardly through the sealing lip **26**. The central portion **21** of the seal body is then expanded outwardly causing the upper hooked ends **16** of the wires to move upwardly somewhat in the ring **30**.

It will be noted in FIGS. 4 and 5 that the lower end of the leg **2** or skirt guide **5** has a pair of bolted rings **42** and **43**, the upper one of which is welded to the bottom of leg **2** or skirt guide **5**. These rings have a recess to recess to receive the annular bead **44** of a fabric-reinforced diaphragm **45** which is strong enough to keep water from entering the lower end of the hollow-platform member when the drilling platform is being floated to a drilling site, but which diaphragm **45** is ruptured when the pile **6** is driven downwardly therethrough as shown in FIG. 5. When this occurs the diaphragm no longer can seal and prevent the entry of dirt as shown by the arrows D near the bottom of FIG. 5. At the time that the pile **6** is being driven there is no cement in the annulus above the seal **8** and therefore, if the seal were not effective to stop the entry of fluid travelling in the upward direction, the dirt and debris surging into the annulus between the pile **6** and the leg **2** or skirt guide **5** would contaminate and compromise the integrity of the cement C which is poured into the annulus as soon as the pile **6** is fully driven. It is for this reason that the downwardly extending lip **26** is provided so that the dirt entering along the direction of the arrows at the bottom of FIG. 5 will be excluded from the annulus when the diaphragm **45** is ruptured and while the pile is being driven before the cement C is poured into the annulus.

Once the pile **6** has been driven as far as it can be set into the bottom of the sea, the cement C is then poured into the annulus as shown in FIG. 5. This column of cement, before its is hardened, may be extremely heavy in view of the fact that it can be as much as 80 or more feet high, and therefore the seal must be quite sturdy in order to support it until it is hardened and the hollow platform member and pile are made into a unitary structure thereby. As pointed out above, the upwardly extending lip **25** is pressed tightly against the inner surface of the hollow platform member, whether it be a leg or a skirt guide, by the weight of the liquid above it.

The elastomeric body bears the weight of the cement column in the annulus and is itself supported both from below by the ring **31** and from above by the ring **30** exerting longitudinal holding forces on the wires **10**. The central portion of the elastomeric body at **21** is pressed tightly against the outer surface of the pile **6**, while the lip **25** seals the lower end of the body tightly against the wall of the hollow platform member as stated above. The open spaces between the wires **10** in the vicinity of their upper portions permit the entry of cement into the space immediately adjacent to the elastomeric body while the cement is being poured in liquid state.

Having thus described my invention in terms of a practical illustrative embodiment, I now present the following claims:

1. A seal for sealing the annulus between the inner surface of a hollow member and the outer surface of a pile passing substantially coaxially therethrough and having a smaller diameter than said inner surface, comprising:

(a) an annular series of spaced resilient wires, the wires lying in different circumferentially spaced planes and each wire having an upper end portion and a lower end portion respectively lying against said inner surface of the hollow member and said end portions being connected by a central portion joined to the upper end portion and bowed downwardly and radially inwardly and then bowed downwardly and outwardly to join said lower end portion;

(b) means fixed to the inner surface of the hollow member for captivating said upper and lower end portions against said inner surface; and

(c) an elastomeric seal body in said annulus surrounding and embedding said wires end extending from the lower end portions thereof to include the downwardly and outwardly bowed portions of said central portions, and the body sealing against both said inner and outer surfaces.

2. In a seal as set forth in claim 1, said captivating means comprising circumferential axially-opposed ring means fixed in mutually-spaced relation to said inner surface, and the outer extremities of said end portions being engaged between the inner surface of the hollow member and the ring means and having hooked tips to prevent withdrawal therefrom.

3. In a seal as set forth in claim 2, the hooked tips at either end of each wire being spaced further apart than the captivating ring means to permit axial lengthening and fore-shortening of the seal due to movements of its central portion in radial directions.

4. In a seal as set forth in claim 2, pile deflecting means located above the captivating means and tapered to engage a pile being lowered through the seal and deflect it inwardly of the hollow member and prevent it from contacting said captivating means.

5. In a seal as set forth in claim 1, the central portion of each wire including a downwardly and radially inwardly tapering upper length and a downwardly and outwardly tapering lower length joined by an axially disposed center length adapted to lie against the outer surface of the pile, and the elastomeric body completely

embedding said lower lengths but only partially embedding said center lengths such that the center lengths lie tangent to the outer surface of the pile and the body lies against said outer surface and completely fills the spaces between the center lengths.

6. In a seal as set forth in claim 5, the body surrounding the lower lengths of said central wire portions and extending from engagement with the outer surface of the pile to engagement with the inner surface of the hollow member, the body having a downwardly extending lip descending along the outer surface of the pile beyond the center lengths of the wires and, when in relaxed condition, curving radially inwardly of the seal so that the lip will lie tightly against the pile when the latter is passed through the seal.

7. In a seal as set forth in claim 5, the body surrounding the lower lengths of said central wire portions and extending from engagement with the outer surface of the pile to engagement with the inner surface of the hollow member, and the body partially surrounding the lower portions of the wires so that it fills the spaces between the wires which lie tangent to the inner surface of said member, and said body having an upwardly extending lip rising along the inner surface of said member and forming an acute angle with the body surrounding the lower lengths of said central portions.

8. In a seal as set forth in claim 5, the body terminating near the tops of said center wire lengths, and the body tapering upwardly and radially outwardly to prevent snagging of the body by the end of a pile being lowered through the seal and guided by the inner surfaces of its wires.

9. In combination with a seal as set forth in claim 1, rupturable means extending across and closing the lower end of the hollow member, and adapted to be broken by a pile when driven through the seal and through the rupturable means.

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J. KARL BELL, Primary Examiner

U.S. Cl. X.R.

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