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(54) **An electric power distribution cable and a power distribution arrangement provided therewith**

(57) An electric power distribution cable (1), comprising a conductor (2), an electric insulation (3) enclosing said conductor (2), and a water impermeable metallic sheath (5) enclosing and protecting said electric insulation (3). The cable (1) comprises an electrically conducting element (7) extending in the longitudinal direction of the cable (1) and electrically connected to the metallic sheath (5).

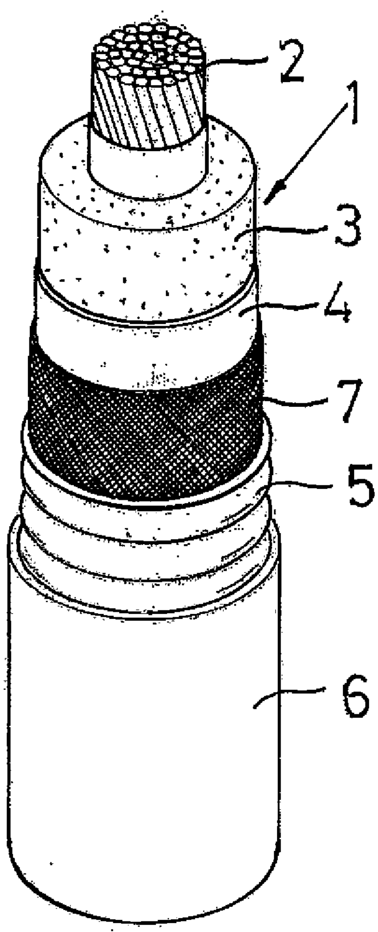

Fig 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an electric power distribution cable, comprising a conductor, an electric insulation enclosing said conductor, and a water impermeable metallic sheath enclosing and protecting said electric insulation. It also relates to an electric power distribution arrangement comprising an electric power distribution cable extending in open sea from the sea surface to a bottom region thereof.

[0002] The above-mentioned electric conductor is the conductor through which the electric current is distributed. The metallic sheath has as its task to prevent water from reaching and damaging the electric insulation. It will, normally, also have as its task to carry a current, the so called earth current. The cable will also, normally, have further layers, apart from those mentioned, such as a protective layer that encloses the metallic sheath and protects it from the environment. A plural phase cable may have a corresponding plurality of such parts as the one defined above, enclosed in further layers.

[0003] The cable according to the invention may be a high voltage alternating current (HVAC) cable, either in an electric single phase system or an electric three phase system. The cable may also be a high voltage direct current (HVDC) cable. High voltage is referred to as voltages of 1 kV and above.

BACKGROUND OF THE INVENTION

[0004] A modem power distribution cable adapted to be used as a sea cable comprises an electric conductor, an electric insulation enclosing said conductor, and a metallic sheath that encloses the electric insulation and prevents water from reaching and damaging the latter.

[0005] Dynamic power distribution cables connected to floating platforms or vessels are subjected to repeated movements induced by the motion of the sea. Due to this the cable is subjected to fatigue. Thereby, the metallic sheath is a critical component, and might be subjected to the upcoming of cracks therein or even failure. The movements and the fatigue are largest at the top location, i.e. close to the connection point to the platform or vessel. This location is often above sea level.

[0006] In case that the sheath cracks so badly that no electrical earth connection exists anymore through the latter, sparks will occur at the sheath in the crack region, and those sparks will, eventually, deteriorate the underlying part. If nothing is done, a full break-down of the cable will occur sooner or later. This will result in a full shut down of the power distribution through the cable, which might be very costly.

THE OBJECT OF THE INVENTION

[0007] It is an object of the present invention to provide a power distribution cable of a design that prevents damaging of underlying vital parts of the cable upon cracking of or failure on the metallic sheath that is provided for the purpose of preventing water intrusion into the underlying electric insulation of the cable and of carrying an earth current.

SUMMARY OF THE INVENTION

[0008] The object of the invention is achieved by means of the initially defined cable, **characterised in that** the cable comprises an electrically conducting element extending in the longitudinal direction of the cable and electrically connected to the metallic sheath. In case the metallic sheath fails, i.e. breaks or cracks, the electrically conducting element will take over the electrical function thereof, i.e. conduction of the earth current. Preferably, the electrically conducting element extends continuously in the longitudinal direction of the cable, i.e. Continuously is referred to as without any interruption of its electric conducting ability in the longitudinal direction of the cable, and over a certain distance, at least 5 metres, preferably at least 25 metres or even at least 50 metres, depending on the specific application in which the cable is used.

[0009] According to a preferred embodiment the electrically conducting element extends in the circumferential direction of the cable. Preferably, the extension in the circumferential direction is of a magnitude that will increase the possibility that the electrically conducting element will be located also in circumferential region where a crack might be initially formed in the metallic sheath. Thereby, the electrically conducting element may play a vital spark-inhibiting role also at early stages of crack formation and propagation in the metallic sheath. Should the conducting element only have a delimited extension in the circumferential direction of metallic sheath, a crack in the latter may occur in a region where there is not provided an electrically conducting element. Thereby, sparks in the region of the crack will not be inhibited by the conducting element, resulting in unwanted effect on the inner layers, in particular on the electric insulation. Preferably the extension of the conducting element in the circumferential direction is generally continuous, preferably in each cross-section of the cable, i.e. all along the length of the cable. Absolute continuity is not required, as will be seen in the following description.

[0010] According to a preferred embodiment the metallic sheath is arranged to carry an earth current during operation of the cable, wherein the electrically conducting element has an electric conductance enabling it to carry said earth current in case of failure of the metallic sheath. Thereby, the whole earth current normally carried by the metallic sheath may be carried by the electrically conducting element upon total break of the sheath somewhere along the cable.

[0011] Though, in a wide meaning of the invention, the electrically conducting element may be located radially outside the metallic sheath, it is preferred that the electrically conducting element be located inside the metallic sheath as seen in a radial direction. Thereby, the electrically conducting element is protected by the metal sheath from the impact of the outside environment.

[0012] Preferably, the electrically conducting element is adapted to form an electric barrier preventing partial discharges generated at the metallic sheath from directly affecting the underlying electric insulation. There are several parameters decisive for the provision of an electric barrier, for example the material properties of the conducting element, its shape and the size of possible meshes or spaces between individual parts thereof, i.e. deviations from an absolutely dense material. If the element is dense enough, it will, from an electric point of view, form a barrier that will prevent sparks generated at a crack of the metallic sheath from reaching and affecting the underlying electric insulation.

[0013] According to one embodiment of the invention, the electrically conducting element comprises an electrically conducting net, preferably a metal net. The meshes of the net should be below a predetermined size such that the net will prevent sparks generated at possible cracks in the metallic sheath from reaching and destroying the electric insulation located radially inside said net.

[0014] According to a further embodiment, the electrically conducting element comprises an electrically conducting sheath. Preferably, such a sheath will fully cover the adjacent inner layer of the cable and present an electric barrier with regard to sparks or discharges generated at possible cracks in the metallic main sheath of the cable. The sheath of the electrically conducting element may be formed by a thin strip, preferably a metal strip, wound around the adjacent inner layer.

[0015] According to a further embodiment, the electrically conducting element comprises at least one electrically conducting wire wound in a helix along the cable. The number of wires, the diameter of each wire, and the pitch with which they are wound will be decisive for the functionality of the electrically conducting element. Preferably, said parameters are chosen such that an electric barrier against sparks from the metallic sheath is formed. A plurality of wires is preferred, since then a redundancy will be provided for.

[0016] Preferably, the electrically conducting element is in electrically connected to, preferably in physical contact with, the metallic sheath continuously in the longitudinal direction of the cable. Continuously is referred to as without interruption or with short interruptions. If, for example, the metallic sheath presents a repeatedly ondulating or wave-shaped or irregular surface towards the electrically conducting element, such wave-shape or irregularity may result in a repeatedly broken but still generally continuous electric and physical contact between the metallic sheath and the electrically conducting element. Such embodiments should be included in the scope of the invention. Thereby, a continuous electric connection between the metallic sheath and the electrically conducting element will be guaranteed. In case of failure of the metallic sheath, the distance over which the electrically conducting element conducts the whole earth current will be short, corresponding to the width of the failure crack or the distance between two adjacent contact points or contact lines between metallic sheath and conducting element on opposite sides of such a crack. In this context it should be mentioned that, of course, the electrically conducting element may also be of a design that will result in a generally but not absolutely, continuous electric and/or physical contact in the longitudinal direction between the conducting element and the metallic sheath. It should be mentioned that an electric contact may be provided between the sheath and the conducting element also without the provision of a direct physical contact therebetween. A thin layer of a dielectric medium may physically separate the two components, but not prevent an earth current from being transferred from the sheath to the conducting element as seen over longer distances. However, in most cases a direct physical contact between sheath and conducting element is preferred.

[0017] Preferably, the electrically conducting element is in electric contact, and preferably also physical contact, with the metallic sheath continuously in the circumferential direction of latter. "Continuously in the circumferential direction" may be referred to as described above for the expression "continuously in the longitudinal direction", i.e. including embodiments in which there might be short interruptions of such continuity.

[0018] According to an alternative embodiment, the electrically conducting element comprises two or more electrically connected, electrically conducting sub-layers. Each such sub-layer may, for example, comprise any of an electrically conducting net, at least one helically wound electrically conducting wire or a sheath, as described earlier in this document. The use of more than one layer may contribute to a more redundant and versatile design, since individual sub-layers may be optimised with respect to different main tasks (earth current conduction, spark barrier).

[0019] It is preferred that the electrically conducting element has a higher fatigue strength with regard to repeated bending thereof than has the metallic sheath. Should this not be the case, cracking of the electrically conducting element might coincide with cracking of the metallic sheath, detrimental for the cable. The electrically conducting element should also have a higher flexibility than the metallic sheath, in order to avoid that both said element and the metallic sheath would crack or break simultaneously due to a single bending of a magnitude sufficient for breaking the metallic sheath.

[0020] The object of the invention is also achieved by means of the initially defined electric power distribution arrangement, **characterised in that** said cable is provided with an electrically conducting element in accordance with the invention at least along a part thereof that is subjected to motions caused by the motion of the sea.

The cable extends from a vessel or a platform on the sea. Typically, the region in which a cable extending from the sea surface to the sea bottom is most subjected to motions that might result in cracks and failure of the metallic sheath thereof is an upper part.

Since a very long part of such a cable will be less subjected to such motion, the invention includes that only a part of the cable be provided with said electrically conducting element, i.e. the part subjected to such motions. For example, a link box may be provided at a certain level below a top connection of the cable, either in air or in water, wherein only the part of the cable that extends from the top connection to said box may be provided with said electrically conducting element, and the part of the cable that extends further from said box be without such an element. Thereby, only those parts of a sea cable that are severely subjected to motion that might induce failure of the metallic sheath are provided with the electrically conducting element according to the invention.

[0021] Further features and advantages of the invention will be described in the following

detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The invention will now be described more in detail with reference to the accompanying drawing on which.

Fig. 1 is a schematic representation of a cable according to a first embodiment of the invention,

Fig. 2 is a schematic representation of a second embodiment of the cable of the invention,

Fig. 3 is a schematic representation of a third embodiment of the cable according to the invention,

Fig. 4 is a representation of a three-phase cable provided with three individual phases in accordance with the invention, and

Fig. 5 is a schematic representation of a power distribution arrangement according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Fig. 1 shows a first embodiment of a cable of the invention. The cable, indicated with 1, comprises three identical parts, one for each electric phase in a three-phase system. For reasons of clarity, only one of said parts, to which reference is made, is shown more in detail. Each part comprises an electric power conductor 2, an electric insulation 3, preferably made of a polymer, a bedding 4 surrounding the electric insulation 2, and a metallic sheath 5 that encloses the above-mentioned components. The metallic sheath 5 is in its turn surrounded by further layers, including further layers and, possibly, metal wire layers, that protect the inner parts of the cable. Said further layers, indicated with reference number 6, may also have further functions, but will not be described more in detail in this application, since they are regarded as less relevant for the principles of the invention. The cable shown in fig. 1 is a HVDC cable. However, the features hereinafter described are also relevant and applicable to other cables, such as single phase HVAC cables or plural phase HVAC cables. The components of the cable that will be described herein are assumed to extend continuously in the longitudinal direction of the cable.

[0024] Between the metallic sheath 5 and the bedding 4 there is provided an electrically conducting net-shaped element 7, which is in direct physical and electrical connection with the metallic sheath 5. The electrically conducting element 7 will supplement the metallic sheath 5 as a carrier of earth current. It is has a higher flexibility than the metallic sheath 5, and presents a higher fatigue strength than the latter with regard to repeated bending thereof. Its interaction with the metallic sheath 5 and its supplementary function will be described more in detail later. It may be made of a metal such as copper or steel.

[0025] The metallic sheath 5 has as one of its tasks to protect the electric insulation 3 from intrusion of water, either in a liquid or gaseous state, since water, and especially salt water, will deteriorate the insulation if permitted to act thereon during a long period. For this purpose, the sheath 5 is made of a metal and is totally water-impermeable. The sheath 5 also has as its tasks to carry an earth current, and to restrain or control an electric field generated by the electric conductor 2. Preferably, the sheath 5 is formed by a corrugated tube of metal, preferably formed by a copper or aluminium alloy.

[0026] The electrically conducting net 7 works as a supplementary earth current carrier in case of any cracking or similar functionality failure of the metallic sheath 5 by which the latter is unable of carrying the current along a certain section of the cable length. The net 7 has a conductance enabling it to carry the full earth current during a substantial length of time, during which replacement of the damaged cable or cable section is provided for. Accordingly, it should be able of carrying an electric current of several Amperes.

[0027] Fig. 2. shows an alternative embodiment of a cable 8 in which the electrically conducting element 9 is formed by a plurality of wires wound helically around the bedding 4 and electric insulation 3. Likewise to the net of the previous embodiment the wires of the conducting element 9 are preferably made of a metal such as copper or steel.

[0028] Fig. 3 shows a further alternative embodiment of a cable 10 in which the electrically conducting element 11 is formed by a sheath formed by a film or tape wound helically, with overlapping turns, around the adjacent inner layer, i.e. the bedding 4. The sheath 11 totally covers the adjacent inner layer, thereby forming a protective layer protecting the underlying layer from possible sparks that might emanate between opposite sides of a crack in the metallic sheath 5 that surrounds the electrically conducting element 11. Preferably, the sheath of the electrically conducting element 11 is made of a metal alloy such as copper or steel. Likewise to the net and wires of the previous embodiments, it has a higher flexibility than the metallic sheath 5, a higher fatigue strength than the latter, and is able of carrying the whole earth current upon an interruption of the ability of the metallic sheath 5 to carry said current, typically caused by a fracture therein.

[0029] Fig. 4 shows a three-phase HVAC cable 20, comprising three phases or parts 15, 16, 17, each of which may be designed in correspondence to the cables 1,8, 10 described in the previous embodiments, i.e. comprising a conductor 2, an electric insulation 3, possibly a bedding 4, a metallic sheath 5, and surrounding layers (here indicated with 18). A further conducting element or layer 19, corresponding to any one of the further electrically conducting elements 7, 9, 11 of the already described embodiments is located inside and in electric contact with the associated metallic sheath 5 in the same way as described for the conducting elements of figs. 1-3.

[0030] Fig. 5 shows a power distribution arrangement according to the invention. The arrangement comprises a cable 1 according to the invention extending from a surface region or a region in which it is connected to a off-shore platform 12 down to a link box 13 at a predetermined depth below the surface or the connection to the platform 12. In the link box the cable 1 according to the invention is connected to a cable 14 which is not provided with the conductive element according to the invention, and which extends over a distance that is substantially longer than that of the cable 1 of the invention. The length of the part formed by the cable 1 of the present invention is determined upon basis of the assumed motions of the sea and the flexibility and fatigue strength of the other cable part 14, i.e. the part that is not provided with the electrically conducting element. The cable 14 not provided in accordance with the invention should only extend in regions in which that cable is less subjected to motions that might induce fractures in and failure of the metallic sheath thereof.

Claims

1. An electric power distribution cable (1, 8, 10, 20), comprising a conductor (2), an electric insulation (3) enclosing said conductor (2), and a water impermeable metallic sheath (5) enclosing and protecting said electric insulation (3), **characterised in that** the cable comprises an electrically conducting element (7, 9, 11, 19) extending in the longitudinal direction of the cable (1, 8, 10, 20) and electrically connected to the metallic sheath (5).

2. An electric power distribution cable (1, 8, 10, 20) according to claim 1, **characterised in that** the electrically conducting element (7, 9, 11, 19) extends in the circumferential direction of the cable (1, 8, 10, 20).

3. An electric power distribution cable (1, 8, 10, 20) according to claim 1 or 2, **characterised in that** the metallic sheath (5) is arranged to carry an earth current during operation of the cable (1, 8, 10), and that the electrically conducting element (7, 9, 11, 19) has an electric conductance enabling it to carry said earth current in case of failure of the metallic sheath (5).

4. An electric power distribution cable (1, 8, 10, 20) according to any one of claim 1-3, **characterised in that** the electrically conducting element (7, 9, 11) is located inside the metallic sheath (5) as seen in a radial direction.

5. An electric power distribution cable (1, 8, 10, 20) according to any one of claims 1-4, **characterised in that** the electrically conducting element (7, 9, 11, 19) is adapted to form an electric barrier preventing partial discharges generated at the metallic sheath (5) from directly affecting the underlying electric insulation.

6. An electric power distribution cable (1) according to any one of claims 1-5, **characterised in that** the electrically conducting element (7) comprises an electrically conducting net.

7. An electric power distribution cable (10) according to any one of claims 1-6, **characterised in that** the electrically conducting element (11) comprises an electrically conducting sheath.

8. An electric power distribution cable (8) according to claim any one of claims 1-7, **characterised in that** the electrically conducting element (9) comprises at least one electrically conducting wire wound in a helix along the cable (8).

9. An electric power distribution cable (1, 8, 10, 20) according to any one of claims 1-8, **characterised in that** the electrically conducting element (7, 9, 11, 19) is electrically connected to the metallic sheath (5) continuously in the longitudinal direction of the cable (1, 8, 10, 20).

10. An electric power distribution cable (1, 8, 10, 20) according to any one of claims 1-9, **characterised in that** the electrically conducting element (7, 9, 11, 19) is electrically connected to the metallic sheath (5) continuously in the circumferential direction of latter.

11. An electric power distribution cable (1, 8, 10, 20) according to any one of claims 1-10, **characterised in**

that the electrically conducting element (7, 9, 11, 19) comprises two or more electrically connected, electrically conducting sub-layers.

12. An electric power distribution cable (1, 8, 10, 20) according to any one of claims 1-11, **characterised in that** the electrically conducting element (7, 9, 11, 19) has a higher flexibility than has the metallic sheath (5).

13. An electric power distribution cable (1, 8, 10, 20) according to any one of claims 1-12, **characterised in that** the electrically conducting element (7, 9, 11, 19) has a higher fatigue strength with regard to repeated bending thereof than has the metallic sheath (5).

14. An electric power distribution arrangement, comprising an electric power distribution cable (1, 8, 10, 20) extending in open sea from the sea surface to a bottom region, **characterised in that** said cable (1, 8, 10, 20) is provided with an electrically conducting element (7, 9, 11, 19) in accordance with any one of claims 1-12 at least along a part thereof that is subjected to motions caused by the motion of the sea.

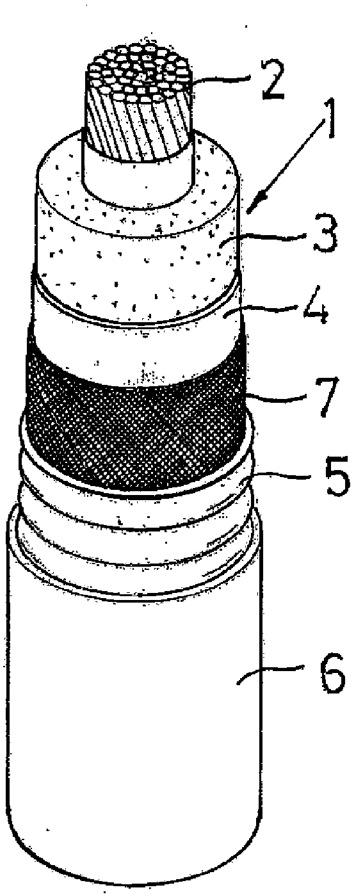

Fig 1

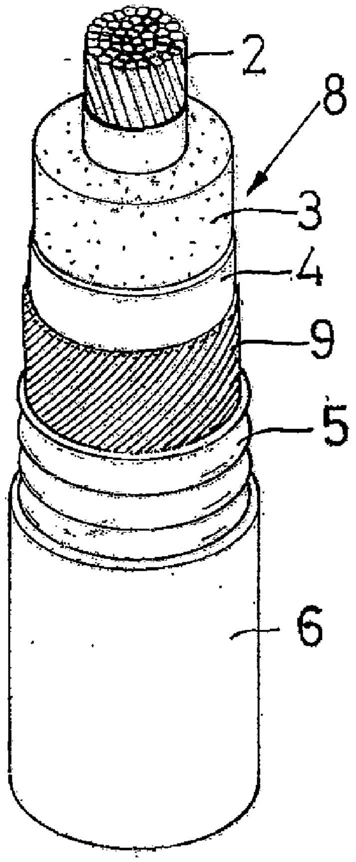

Fig 2

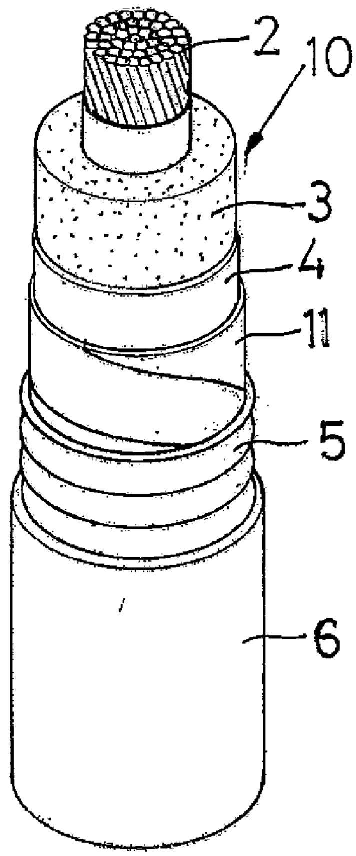

Fig 3

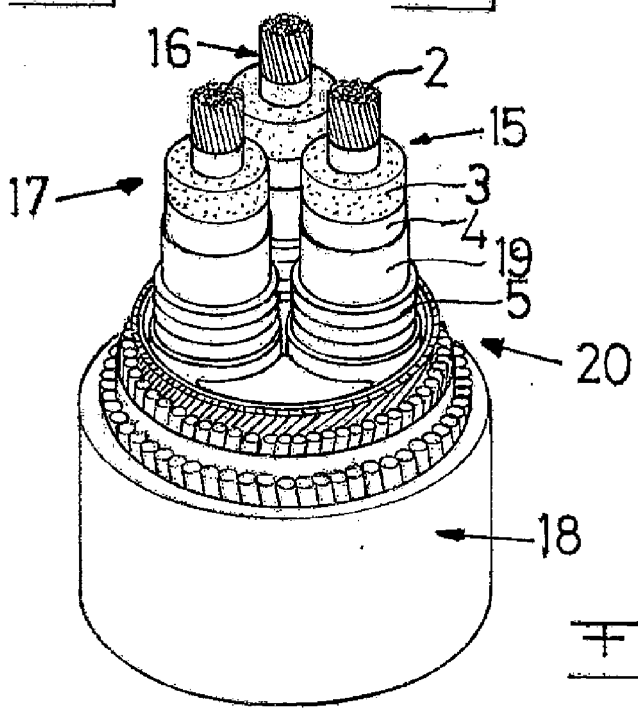

Fig 4

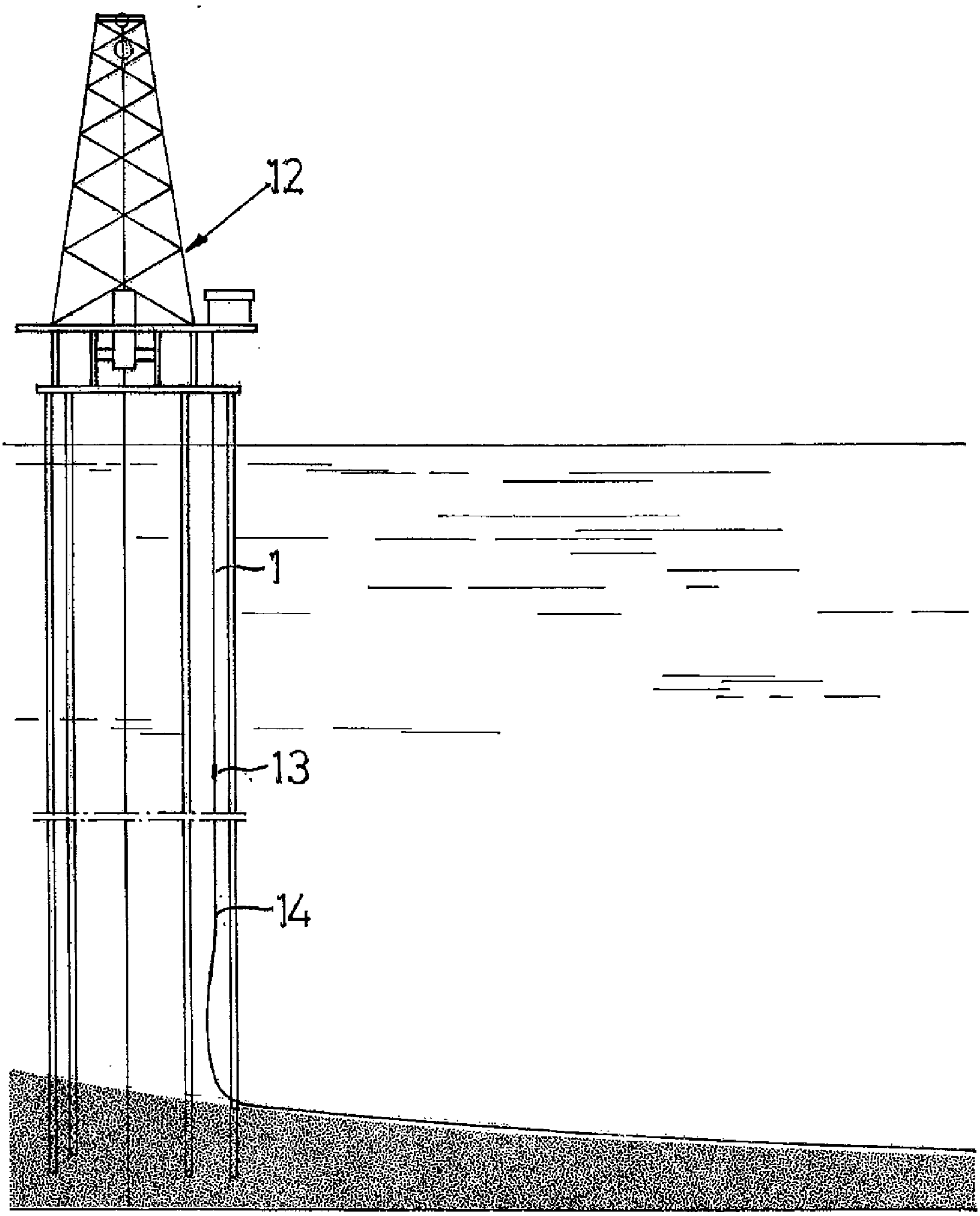

Fig 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 10 1792

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 July 2008	Hillmayr, Heinrich

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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