(19) DANMARK

(10) **DK/EP 3240932 T3**

Patent- og Varemærkestyrelsen

(12) Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***E 02 B 17/00 (2006.01)*** ***E 02 D 7/02 (2006.01)*** ***E 02 D 13/00 (2006.01)*** ***E 02 D 27/52 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2022-02-14**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2021-12-01**

(86) Europæisk ansøgning nr.: **15837148.4**

(86) Europæisk indleveringsdag: **2015-12-29**

(87) Den europæiske ansøgnings publiceringsdag: **2017-11-08**

(86) International ansøgning nr.: **NL2015050917**

(87) Internationalt publikationsnr.: **WO2016108692**

(30) Prioritet: **2014-12-29 NL 2014069**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **IHC Holland IE B.V., Molendijk 94, 3361 EP Sliedrecht, Holland**

(72) Opfinder: **JUNG, Boudewijn Casper, , 4614 AK Bergen op Zoom, Holland**
VAN VESSEM, Henricus Gerardus Andreas, , 5261 AX Vught, Holland

(74) Fuldmægtig i Danmark: **Patrade A/S, Ceresbyen 75, 8000 Århus C, Danmark**

(54) Benævnelse: **Fremgangsmåde til installation af et fundamentelement og støjdæmpningssystem**

(56) Fremdragne publikationer:
EP-A2- 2 441 892
EP-B1- 1 640 508
WO-A2-2010/151121
JP-A- S60 159 218
None

DESCRIPTION

[0001] The invention relates to a method of installing a foundation element, in particular a monopile, in an underwater ground formation by means of a driver, comprising the steps of placing a foundation element on the underwater ground formation, e.g. directly on a river- or seabed or on a scour protection or rock formation, placing a screen for reducing noise input from the driver into surrounding water, and driving the foundation element into the ground formation by means of the driver while the screen is positioned about the foundation element. The invention further relates to a noise mitigation system comprising a screen to be placed about a foundation element. The document "Development of Noise Mitigation Measures in Offshore Wind Farm Construction 2013" describes on page 17 the result achieved in noise mitigation by using two screens formed of bubble curtains positioned at a distance from each other.

[0002] As explained in WO 2007/096132, offshore ramming work is carried out under water to establish foundations, for example, for drilling platforms and wind turbines. For wind turbines, large monopiles with a diameter of more than four meters are rammed into the seabed. This ramming results in a substantial underwater noise input, which can have a negative impact on marine fauna. To reduce the noise input underwater, in the method and device according to WO 2007/096132, the material that is to be rammed is surrounded by a fixed flooded sleeve. The sleeve advantageously has a sandwich-like structure.

[0003] EP 1 640 508 relates to a guide device for piles, the device having a frame fastened on a ship-jack-up rig for encompassing and guiding a post, when ramming the post in a benthic division. A nozzle assembly of a blowing device, which can be lowered from an upper standby position underneath the frame into an operating position at the benthic division, is attached at the frame.

[0004] WO 2010/151121 relates to a device for the passive reduction of the sound vibrations in a liquid resulting from a sound source arranged below the liquid level of a body of water, the device comprising an elongate tube which can be arranged over the sound source, the tube comprising an outer wall and inner wall, wherein the tube is designed to maintain a certain desired pressure in the intermediate space between the inner and outer wall. In this case, the pressure is reduced with respect to the ambient pressure. As a result of the reduced pressure, the sound vibrations will less readily travel to the outside and the noise level in the area around the tube is reduced. "The outer wall and inner wall of the tube can be provided one after the other in the body of water, for example by first anchoring the inner wall into the bottom and then anchoring the outer wall which is arranged around it into the bottom. However, it is also possible to place the tube as a whole, that is to say with the inner and outer wall already assembled to form a single part, on the bottom."

[0005] EP 2 441 892 A2 relates to a sound insulation device which "has a sleeve (20), which surrounds a pile (1) inserted in a sea floor (2). The bubbling (23) is formed between the sleeve

and the pile inserted in the sea floor. Another sleeve (30) is provided, which surrounds the former sleeve. A sound-absorbing material (33) is introduced between the two sleeves."

[0006] It is an object of the present invention to further improve noise mitigation.

[0007] To this end, the method of the present invention comprises deploying, before driving the foundation element into the ground formation, a further screen about the first screen.

[0008] Surrounding the foundation element, during driving, by a first noise mitigation screen and at least a further noise mitigation screen, flexibility in optimizing and/or effectiveness of noise mitigation is improved. E.g., the first screen, the further screen and the distance between the screens can be optimized for mitigation of different frequency ranges. In an example, the first screen comprises a solid sleeve and the further screen is a bubble screen or comprises air chambers.

[0009] In an embodiment, the first screen provides a noise reduction of at least 15 dB, e.g. a noise reduction in a range from 17 to 25 dB, and the further screen provides a noise reduction of at least 5 dB, e.g. a noise reduction in a range from 6 to 15 dB.

[0010] In another embodiment, the further screen is deployed from the first screen, e.g. the further screen comprises a plurality of arms attached to the first screen and these arms are translated and/or rotated to deploy the further screen. Thus, the screens can be put in place as a whole and/or by means of the same equipment and, when the first screen is in place, the further screen can be folded out.

[0011] In another embodiment, a ring, continuous or intermittent, is placed about the first screen, e.g. on the ground formation, and a bubble screen is generated from the ring and/or a buoyant screen is suspended from the ring.

[0012] In an embodiment, the further screen is deployed with its bottom end below the bottom end of the first screen. In another embodiment, the further screen is deployed at a distance, measured between the outer circumference, e.g. the outer wall, of the first screen and the outer circumference, e.g. the outer wall or perimeter, of the further screen, of at least 3 meters, preferably at least 5 meters, preferably at least 7 meter, and/or preferably less than 50 meter, preferably less than 40 meters, preferably less than 30 meters, preferably less than 20 meters. Thus, the further screen can be deployed also about objects, such as a rock formation or scour protection, that the first screen is placed on or in and noise transmitted via such objects mitigated with the further screen.

[0013] The invention further relates to a noise mitigation system comprising a first screen to be placed about a foundation element, in particular a monopile, during driving of the foundation element in an underwater ground formation, to reduce noise input resulting from the driving into the surrounding water, e.g. a river or sea, and a further screen to be deployed about the first screen.

[0014] According to the invention, the further screen is attached to the first screen and movable between a retracted position and a deployed position, the further screen comprises a plurality of arms slidably and/or pivotably attached to the first screen, e.g. pivotable about a substantially vertical or a substantially horizontal axis.

[0015] In another embodiment, the further screen comprises a series of nozzles or a buoyant screen, e.g. a flexible tube comprising one or more buoys or air chambers.

[0016] In a refinement, the system comprises a tube or duct provided with a plurality of nozzles and attached near or at the ends of the arms, for generating a so-called bubble screen.

[0017] In another embodiment, the bottom end of the further screen is deployable below the bottom end of the first screen, e.g. by lowering the further screen from the first screen of by pivoting arms about horizontal axes over an angle between the arms and the first screen of more than 90°, preferably more than 100°. Surrounding e.g. a rock formation or scour protection is facilitated, if the further screen, e.g. the arms, is attached to the first screen at least 1 meter, preferably at least 2 meters, above the bottom end of the first screen.

[0018] For the sake of completeness, attention is drawn to the following prior art.

[0019] JP 60-159218 discloses a sound insulator for a pile hammer comprising sound insulating cylinders, which are formed from a resilient material and in the shape of bellows. The sound insulating cylinders are secured around a pile.

[0020] DE 1 784 396 discloses a pile driving hammer comprising a telescopic sound absorbing sleeve.

[0021] EP 2 395 156 relates to a method of installing foundation elements, in particular monopiles, comprising the steps of placing a foundation element on the underwater ground formation and holding the foundation element in place by means of a gripper mounted on a surface vessel.

[0022] T.J. Carlson et al., "Hydroacoustic Measurements During Pile Driving at the Hood Canal Bridge, September Through November 2004" discloses a HDPE pipe sleeve that fits over a 24 inch (about 60,96 cm) pile and reaches from a point above water to the ground elevation below water. The mentioned sleeve diameter and wall thickness are 34 inch (about 86, 36 cm) and 1 3/8 inch (about 3,5 cm), respectively.

[0023] The invention will now be explained in more detail with reference to the Figures, which show a preferred embodiment of the present method and system.

Figure 1 is a perspective view of noise mitigation system according to the present invention comprising a further screen in a retracted position.

Figure 2 is a perspective view of noise mitigation system according to the present invention comprising a further screen in a deployed position.

[0024] It is noted that the Figures are schematic in nature and that details, which are not necessary for understanding the present invention, may have been omitted.

[0025] Figure 1 shows an embodiment of a system 1 according to the present invention for installing a monopile 2 in an underwater ground formation 3, e.g. a seabed. In this example, the monopile 2 has a circular cross-section and a diameter of five meters and is intended to serve, after installation, as the foundation of a wind turbine.

[0026] The system 1 comprises an hydraulic driver 4 (depicted in Figure 2), e.g. an IHC Hydrohammer S-1800, connected to a power pack on board of a surface vessel, such as a ship or jack-up barge (not shown), a driver sleeve 5 for securely mounting the driver on the monopile and an anvil (hidden from view by the driver screen) for transmitting impact energy from the driver 4 to the monopile.

[0027] The system further comprises a noise mitigation screen 6, made of e.g. steel, to be placed about the foundation element to reduce noise input from the driver into the surrounding water. In this example, the screen comprises an inner wall and an outer wall, i.e. it is double walled, has a circular cross-section and an inner diameter of six meters. In general, it is preferred that, once in place, the sound-insulating screen extends to above the water level W.

[0028] In accordance with the present invention, the system comprises a further screen to be deployed about the screen 6. In this example, a plurality of arms 7 is attached to the first screen 6 by means of hinges 8 and hydraulic cylinders (not shown), such that the arms are pivotable about substantially horizontal axes. The arms have a length of 15 meters and are made of e.g. metal rods or tubes. The hinges are located approximately 2 meters above the bottom end of the first screen 6 and comprise torsion bars (not shown) to facilitate folding out and folding in. A flexible tube 9 is attached to the ends of the arms 7 and provided with a plurality of nozzles.

[0029] Installation of a monopile is carried out for instance as follows. The cables of the crane are attached to the upper end of a monopile stored on the deck of the ship and the monopile is lifted overboard, manipulated to an upright position, lowered onto the seabed or, as in this example, a scour protection 10. At this stage, the monopile is driven, e.g. by means of a vibratory device, into the scour protection and, depending on the circumstances, the seabed to a depth of some meters to further stabilize the monopile.

[0030] The driver is positioned on top of the monopile and the screen is lifted over the monopile and the driver. Alternatively, the screen is placed and the driver is subsequently placed inside the screen and on top of the pile. The further noise mitigation screen is deployed

by lowering the arms onto the seabed. In this position, the tube forms a ring that circumscribes the first screen and the scour protection. By feeding air to the tube, e.g. by means of a pump on deck of a surface vessel and via one or more of the arms, a bubble screen is generated, which screen surrounds the scour protection and the first screen.

[0031] Finally, the pile is driven to the required depth and when driving is completed, the driver is removed, the further screen retracted, the screens lifted over the pile and placed back on deck or into the sea, and installation is completed.

[0032] The invention is not restricted to the embodiment described above and can be varied in numerous ways within the scope of the claims. For instance, the further screen may comprise a buoyant and/or flexible tube, e.g. provided with air chambers or buoys, and the ring may provide sufficient weight to maintain the tube at an appropriate depth, e.g. with it bottom end on or in the seabed.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO2007096132A **[0002]** **[0002]**
- EP1640508A **[0003]**
- WO2010151121A **[0004]**
- EP2441892A2 **[0005]**
- JP60159218A **[0019]**
- DE1784396 **[0020]**
- EP2395156A **[0021]**

Non-patent literature cited in the description

- **T.J. CARLSON et al.**Hydroacoustic Measurements During Pile Driving at the Hood Canal Bridge, 2004, [0022]

Patentkrav

1. Fremgangsmåde til installation af et fundamentelement (2), navnlig en monopæl (2), i en jordformation (3) under vandet ved hjælp af en driver (4), omfattende trinnene til
placering af fundamentelementet (2) på jordformationen (3) under vandet,
placering af en første skærm (6) til at reducere støj fra driveren (4) til det omgivende vand,
at køre fundamentelementet (2) ned i jordformationen (3) ved hjælp af driveren (4), mens den første skærm (6) er placeret omkring fundamentelementet (2), og
at udfolde en yderligere skærm (7, 9) omkring den første skærm (6), før fundamentelementet (2) køres ned i jordformationen (3), og
kendetegnet ved at omfatte udfoldning af den yderligere skærm (7, 9) fra den første skærm (6), hvor den yderligere skærm (7, 9) er udfoldet i en afstand, målt mellem den ydre omkreds af den første skærm (6) og den ydre omkreds af den yderligere skærm (7, 9), på mindst 3 meter, hvor den yderligere skærm (7, 9) omfatter en række arme (7), der er fastgjort til den første skærm (6), og hvor disse arme (7) flyttes og/eller drejes for at udfolde den yderligere skærm (7, 9).

2. Fremgangsmåde ifølge krav 1, der omfatter udfoldning af en ring (9) omkring den første skærm (6) og generering af en bobleskærm fra ringen (9) og/eller ophængning af en svævende skærm fra ringen.

3. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, der omfatter at udfolde den yderligere skærm (7, 9) med dens nederste ende under den nederste ende af den første skærm (6).

4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor den yderligere skærm (7, 9) udfoldes i en afstand, målt mellem den ydre omkreds af den første skærm (6) og den ydre omkreds af den yderligere skærm (7, 9), på mindst 5 meter, fortrinsvis mindst 7 meter, og/eller fortrinsvis mindre end 50 meter, fortrinsvis mindre end 40 meter, fortrinsvis mindre end 30 meter.

5. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor den første skærm (6) reducerer støjen med mindst 15 dB og den yderligere skærm (7, 9) reducerer støjen med mindst 5 dB.

6. Støjdæmpningssystem (1) omfattende en første skærm (6), der skal placeres omkring et fundamentelement (2), navnlig en monopæl (2), under kørsel af fundamentelementet (2) til en jordformation (3) under vandet, for at reducere støj som følge af nedkørslen i det omgivende vand, f.eks. en flod eller et hav, og en yderligere skærm (7, 9), der skal udfoldes omkring den første skærm (6), kendetegnet ved, at den yderligere skærm (7, 9) omfatter en række arme (7) forskydeligt og/eller drejeligt fastgjort til den første skærm (6), og den yderligere skærm (7, 9) er fastgjort til den første skærm (6) og kan bevæges mellem en tilbagetrukket position og en udfoldet position ved at forskyde og/eller dreje armene (7), og hvor, når den yderligere skærm (7, 9) er udfoldet, afstanden mellem den ydre omkreds af den første skærm (6) og den ydre omkreds af den yderligere skærm (7, 9) er mindst 3 meter.

7. Støjdæmpningssystem (1) ifølge krav 6, hvor den yderligere skærm (7, 9) omfatter en række dyser eller en flydeskærm.

8. Støjdæmpningssystem (1) ifølge krav 7, omfattende et rør (9) eller en kanal forsynet med en række dyser og fastgjort til armene (7) nær eller ved enderne af armene (7).

9. Støjdæmpningssystem (1) ifølge et hvilket som helst af kravene 6-8, hvor den nederste ende af den yderligere skærm (7, 9) kan udfoldes under den nederste ende af den første skærm (6).

10. Støjdæmpningssystem (1) ifølge et hvilket som helst af kravene 6-9, hvor den yderligere skærm (7, 9) er fastgjort til den første skærm (6) mindst 1 meter, fortrinsvis mindst 2 meter, over den nederste ende af den første skærm (6).

11. Støjdæmpningssystem (1) ifølge et hvilket som helst af kravene 6-10, hvor afstanden mellem den ydre omkreds af den første skærm (6) og den ydre omkreds af den yderligere skærm (7, 9) er mindst 5 meter, fortrinsvis mindst 7 meter, og/eller fortrinsvis mindre end 50 meter, fortrinsvis mindre end 40 meter, fortrinsvis mindre end 30 meter, fortrinsvis mindre end 20 meter.

DRAWINGS

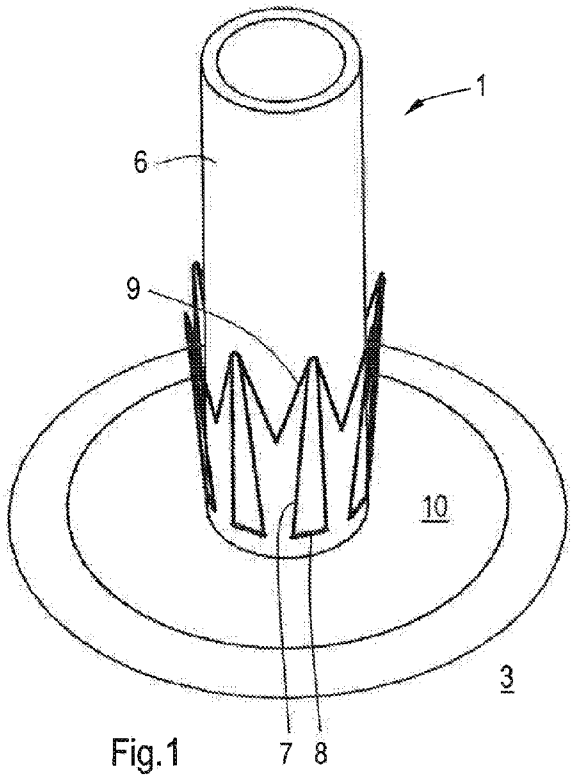

Fig.1

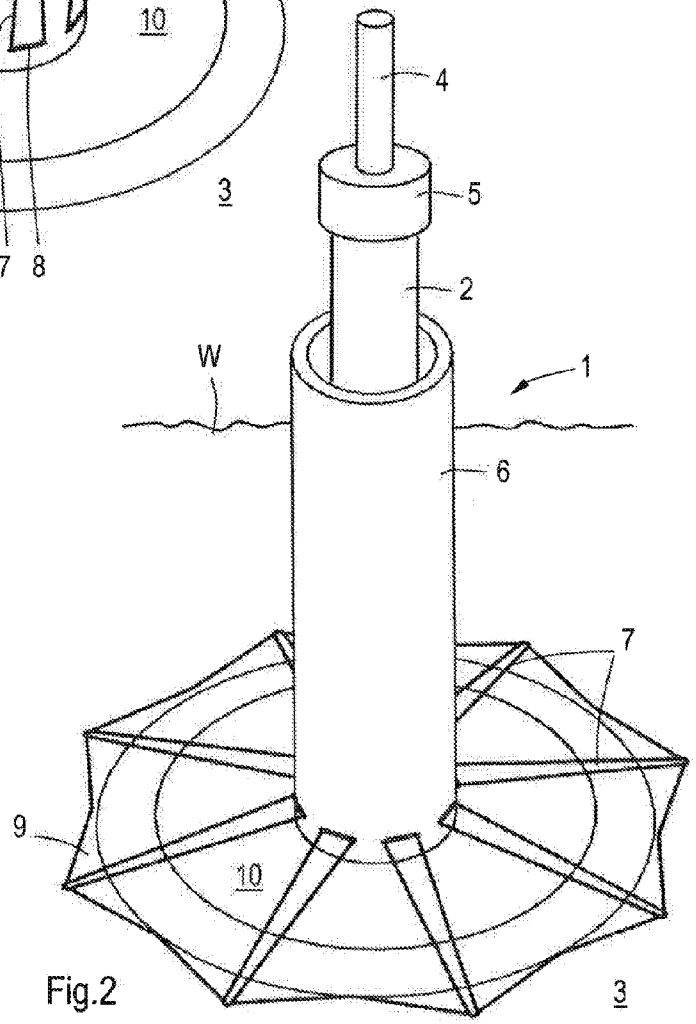

Fig.2