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- (73) Patenthaver: **reamotion GmbH, Schanzenstraße 50a, 27753 Delmenhorst, Tyskland**
Construction Research & Technology GmbH, Dr.-Albert-Frank-Str. 32, 83308 Trostberg, Tyskland
- (72) Opfinder: **Reales Bertomeo, Emilio, Marwedeweg 13, 28355 Bremen, Tyskland**
- (74) Fuldmægtig i Danmark: **RWS Group, Europa House, Chiltern Park, Chiltern Hill, Chalfont St Peter, Bucks SL9 9FG, Storbritannien**
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Description

The invention relates to an offshore supporting structure for a wind energy plant, with one or more fastening means for fastening the supporting structure to the bed of a body of water, a receiving means for receiving a tower shaft of the wind energy plant, and a supporting portion, which has an underwater region and an above-water region and comprises one or more supporting struts, wherein the supporting struts connect the receiving means to the fastening means.

The invention furthermore relates to a method for producing an offshore supporting structure for a wind energy plant, having the steps: coating one or more supporting struts of the supporting structure with a multi-layered protective coating and connecting a plurality of supporting struts together.

Such offshore supporting structures are also referred to as foundation structures and are used for installing wind energy plants in windy offshore districts. The supporting portion of such an offshore supporting structure can be designed, for example, as a jacket, monopile, or tripod structure.

Document DE 20 2012 005 538 U1 discloses such an offshore supporting structure.

The supporting portions of offshore supporting structures always have an underwater region and an above-water region. The underwater region of the supporting portion is subjected to the influences of the currents of the body of water and the milieu prevailing therein. The above-water region of the supporting portion protrudes out of the body of water and is thus also visually perceptible by the shipping industry. The above-water region of the supporting portion is, *inter alia*, subjected to the damp air in the region of the water surface and the prevailing winds. The demands which are placed on the above-water region of the supporting portion therefore substantially differ from the demands which are placed on the underwater region

of the supporting portion.

In addition to the mentioned environmental influences, the underwater region and the above-water region of the supporting portion have to withstand stresses which are induced, for example, by collisions with flotsam or ships, in particular maintenance ships.

It has been shown that not only the above-water region of the supporting portion but rather also the underwater region of the supporting portion of an offshore supporting structure is subjected to a substantial risk of corrosion. This is because microbiological bacteria adhere in the course of time to the supporting struts of the underwater region and as a result, oxygen formation occurs on the surface of the supporting struts due to the bacteria. A continuous corrosion process results there from, which can substantially impair the carrying capacity of the offshore supporting structure.

The object on which the invention is based is accordingly considered that of specifying an offshore supporting structure which has an extended service life and is subjected to lesser risks of damage in comparison to the already known offshore supporting structures. Furthermore, it is an object of the invention to specify a method for producing such an offshore supporting structure. In known structures, rust can already arise in the phase of storage and installation, often months pass until the active corrosion system is connected.

The invention is achieved in a first aspect with an offshore supporting structure of the type mentioned at the outset, wherein one or more supporting struts in the underwater region and one or more supporting struts in the above-water region are coated at least in portions with a multi-layered protective coating.

The invention makes use of the finding that the contact between a corrosion-promoting milieu and the supporting struts can be

substantially reduced or even suppressed entirely both in the underwater portion and also in the above-water portion by means of a multi-layered protective coating. In the underwater region of the supporting portion, the multi-layered protective coating additionally has the effect that the possibility is taken from the microbiological bacteria of adhering directly to the surface of the supporting struts and thus attacking the supporting struts. The oxygen emitted by the bacteria also does not reach the surface of the supporting struts, which are preferably formed from steel, in the underwater region, and therefore no corrosion of the supporting struts begins. Furthermore, the resistance of the offshore supporting structure to external stresses, as can be induced, for example, by collisions with flotsam or ships, can be substantially increased by the material selection of the multi-layered protective coating. The material of the individual layers of the multi-layered protective coating can be selected, for example, such that the supporting struts have an increased stiffness and an increased resistance to wear and abrasion on the coated portions. The individual layers of the multi-layered protective coating can furthermore be selected such that the protective coating has a high tensile strength, good damping properties, and enhanced tear resistance. A multi-layered protective coating which is adapted to the respective water and air temperatures of the offshore district may also be implemented by a suitable material selection. Moreover, a high resistance to oils, greases, oxygen, and ozone may be achieved by the multi-layered protective coating. The multi-layered protective coating can be formed such that it has a cushioning and damping influence in the event of external impact action, for example, due to flotsam, and therefore a reduced force action occurs on the actual supporting struts of the supporting portion of the offshore supporting structure. Furthermore, the degree of hardness of the protective coating can be varied by a suitable material selection or material combination for the individual layers of the protective coating, and therefore, for example, brittle spalling of large-area coating portions is prevented in the event of external force action. Unfavourable vibration properties of the coated supporting strut or struts can also be

compensated for by the multi-layered protective coating.

In a first preferred embodiment of the offshore supporting structure according to the invention, one or more, preferably
5 all the, supporting struts in the underwater region are coated on their outer surfaces and/or substantially completely with the multi-layered protective coating. Alternatively or additionally, one or more, preferably all the, supporting struts in the above-water region are coated on their outer surfaces
10 and/or substantially completely with the multi-layered protective coating. The outer surfaces of the supporting struts in the underwater region are to be understood as the surfaces which come into contact with the water. The outer surfaces of the supporting struts in the above-water region are to be
15 understood as the surfaces which come into contact with the ambient air. If the supporting struts are formed as steel pipes, for example, the outer lateral surfaces of the pipes are thus to be understood as the outer surfaces in the underwater region and in the above-water region. In the case of a complete coating,
20 the inner surfaces of the supporting struts are also coated with the multi-layered protective coating. A complete and full corrosion protection can thus be implemented. This results in a substantially extended lifetime of the supporting structure.

25 According to the invention, an outer paint layer is applied at least in portions to the multi-layered protective coating in the above-water region. An outer paint layer which is formed as resistant to ultraviolet radiation is particularly preferred. The multi-layered protective coating located underneath it can
30 thus be protected from the influence of ultraviolet radiation. The outer paint layer can be applied, for example, directly to the multi-layered protective coating. Alternatively, an additional adhesion promoter or an additional adhesion promoter layer can be applied in order to implement an adhesion of the
35 outer paint layer to the multi-layered coating.

According to the invention, the outer paint layer has coloured pigments. The perceptibility of the above-water region of the

supporting portion and thus the perceptibility of the entire offshore supporting structure is enhanced by the intercalated coloured pigments. A substantially reduced risk of an unintended contact or an unintended collision with a water vehicle results therefrom. In particular in the case of adverse weather conditions, such as strong fog and/or heavy rain, the offshore supporting structure is visually perceived substantially earlier by ship captains traveling by sight as a result of the coloured paint layer on the struts of the supporting structure in the overwater region. The risk of collision is thus significantly reduced.

The offshore supporting structure according to the invention is furthermore advantageously refined in that the coloured pigments are formed as inorganic coloured pigments which retain their optical colour effect under the action of ultraviolet radiation. In this way, it is ensured that fading of the outer coloured paint layer does not occur. The reduced risk of collision due to the enhanced optical perceptibility of the offshore supporting structure is thus always retained. This additionally has the result that it is not necessary to renew the outer coloured paint layer as a result of fading of the colour. The maintenance costs of an offshore supporting structure which has an outer coloured paint layer in the above-water region which retains its optical colour effect under the action of ultraviolet radiation are therefore substantially reduced.

In a further preferred embodiment of the offshore supporting structure according to the invention, the coloured pigments are formed to be yellow. The formation of the coloured pigments in the colour traffic yellow is particularly preferable, which is referred to according to the RAL standard as RAL 1023. The identification of offshore supporting structures by a traffic-yellow colouration is a necessary condition for supporting structures which are set up in offshore districts within the Federal Republic of Germany. It is therefore to be expected that the identification of offshore supporting structures by a traffic-yellow colour design will become the international

standard in the near future.

The offshore supporting structure according to the invention is furthermore advantageously refined in that the multi-layered protective coating has at least one of the following layers: at least one adhesion promoter, preferably two adhesion promoters and, according to the invention, at least one polymer layer, preferably a two-component polymer layer. Due to the use of an adhesion promoter, which is also referred to as a primer, a polymer layer may also be readily applied to struts having a rough surface or a surface having a texture. The processing step of smoothing the outer surface of the struts used, which are preferably formed as steel pipes, is thus omitted. The desired properties of the multi-layered coating may be intentionally set by the use of a polymer layer. In the case of a two-component polymer layer, positive properties of two polymer materials can be coupled to one another, and therefore a particularly rigid, wear-resistant, abrasion-resistant, and tension-resistant and also damping and tear-resistant coating can be implemented.

In one particularly preferred embodiment of the offshore supporting structure according to the invention, the polymer layer comprises polyurethane or is formed substantially completely of polyurethane. Polyurethane is particularly suitable as a coating material, since it is tough and elastically deformable and thus does not tend toward cracking. If a strain of the polyurethane layer occurs, for example, an impression or slashing of the polyurethane layer, an elastic deformation of the polyurethane layer is induced. After the strain is eliminated, the polyurethane layer either assumes the starting state again or a resulting crack is substantially closed again. Furthermore, polyurethane has advantageous damping properties, which have the result that external outer impact strains on the supporting portion are damped before force is introduced into the supporting struts.

The multi-layered protective coating preferably has at least one of the following layers: epoxy resin adhesion promoter, adhesive

adhesion promoter, a polyethylene layer, or a polypropylene layer. The various layers are applied in a layer thickness in a range from 1 mm to 5 mm depending on the desired properties of the resulting multi-layered coating.

5

In a further preferred embodiment of the offshore supporting structure according to the invention, the polymer layer has plasticisers. The elastic properties of the polymer layer may be set precisely by means of plasticisers. Therefore, in
10 dependence on the intended offshore district, various polymer layers tailored to the demands necessary in the respective district may be implemented.

Furthermore, the offshore supporting structure according to the
15 invention is refined by one or more anti-corrosion means which are formed to provide active cathodic corrosion protection. In addition to passive corrosion protection, which is implemented by the multi-layered protective coating, the active cathodic corrosion protection induced by the anti-corrosion means results
20 in a further reduction of the risk of corrosion and thus an extended service life of the offshore supporting structure. The anti-corrosion means can operate in this case, for example, using external current and one or more external current anodes made of titanium, titanium-jacketed copper, or silver-silver
25 chloride. Alternatively or additionally, the use of sacrificial anodes made of magnesium, zinc, or aluminium comes into consideration, which provide corrosion protection even without the use of external current.

30 The object on which the invention is based is furthermore achieved in a second aspect by a method of the type mentioned at the outset, wherein the supporting struts prior to being connected together are coated with the multi-layered protective coating.

35

Because the multi-layered protective coating is coated before the connection or before the intermediate or final assembly of the offshore supporting structure with the multi-layered

protective coating, the production method is substantially simplified and accelerated. It is to be understood that not only the supporting struts of the supporting structure prior to the connecting together of the supporting struts are coated with the multi-layered protective coating, but rather also necessary connecting elements, for example, node points, adapter rings, coupling pieces, or connecting plates, prior to the connecting together of the individual components are also coated with the multi-layered protective coating. Before the actual assembly of the individual supporting structure components, it is possible to move them and thus simplify the application of the multi-layered coating. Furthermore, no inaccessible or poorly reachable strut portions exist yet in this stage of production, the coating of which would require a substantial additional effort. Furthermore, standardized coating methods and coating routines can be introduced, which further reduce the time expenditure and cost expenditure. Furthermore, suitable coating locations and/or structures can be used in order to carry out the coating of the individual components, in particular the supporting struts prior to the actual assembly.

In a first preferred embodiment of the method according to the invention, the coating of the one or the plurality of supporting struts of the supporting structure with a multi-layered protective coating takes place in such a way that the supporting struts are coated on their outer surfaces and/or substantially completely with the multi-layered protective coating. A full corrosion protection is thus already ensured during the storage of the supporting struts before the intermediate or final assembly. An effective corrosion protection therefore already exists after the production of the supporting struts, and therefore the service life of the supporting struts and thus also of the offshore supporting structure is lengthened.

The method according to the invention comprises the following steps:

- applying an outer coloured paint layer, in particular a

paint layer which has yellow coloured pigments and/or which retains its optical colour effect under the action of ultraviolet radiation, to the multi-layered protective coating.

5 The application of the outer coloured paint layer is preferably performed prior to the plurality of supporting struts being connected together. Therefore, coloured supporting struts and possibly components for connecting the coloured supporting struts are already provided before the installation of the
10 offshore supporting structure, and therefore after the joining together or the final assembly of the offshore supporting structure, it already has a coloured paint layer and time-consuming and labour-intensive subsequent painting is not necessary.

15

The method according to the invention is furthermore refined by the following step:

- applying the multi-layered protective coating or the multi-
20 layered protective coating and the outer coloured paint layer to connecting elements and/or connecting portions between supporting struts which are connected together.

After the connecting together of already coated supporting
25 struts, portions regularly arise or connecting elements are used which are not yet coated. To implement a full coating, a subsequent application of the multi-layered protective coating to the not yet coated elements or portions is therefore required. If these elements or portions are located in a region of the
30 supporting structure which is otherwise coloured by means of the coloured paint layer, a subsequent application of the coloured paint layer to the connecting elements and/or connecting portions is also required.

35 In a further preferred embodiment of the method according to the invention, the coating of one or more supporting struts of the supporting structure with the multi-layered protective coating further comprises at least one of the following steps:

- applying, in particular spraying on, at least one adhesion promoter, preferably two adhesion promoters;

5 and, according to the invention,

- applying, in particular spraying on, at least one polymer layer, preferably a two-component polymer layer.

10 The method is furthermore refined according to the invention in that the polymer layer comprises polyurethane or is substantially completely formed from polyurethane and/or the polymer layer has plasticisers.

15 In a further preferred embodiment of the method, it comprises the following steps:

- applying the multi-layered protective coating or the multi-layered protective coating and the outer coloured paint
20 layer to a receiving means for receiving a tower shaft of the wind energy plant; and

- connecting the coated receiving means to one or more supporting struts.

25

Further features and advantages of the invention result from the appended claims and the following description of the figures, in which exemplary embodiments are explained in greater detail on the basis of figures. In the figures:

30

Figure 1 shows an exemplary embodiment of the offshore supporting structure according to the invention; and

Figure 2 shows a schematic illustration of the multi-layered
35 protective coating with an additional outer paint layer.

According to Figure 1, the offshore supporting structure 1 comprises six fastening means 2a, 2b, 2c, 2d, 2e, 2f, by means

of which the supporting structure 1 is anchored on the bed 4 of a body of water. The six fastening means 2a, 2b, 2c, 2d, 2e, 2f are arranged in a common substantially horizontal plane. Furthermore, the six fastening means 2a, 2b, 2c, 2d, 2e, 2f are arranged equidistantly spaced apart from one another on a round circular arc.

The fastening means 2a, 2b, 2c, 2d, 2e, 2f are connected via a supporting portion 8 to a receiving means 6. The receiving means 6 is designed for the purpose of receiving a tower shaft of a wind energy plant.

The supporting portion 8 has an underwater region 8a and an above-water region 8b. The supporting portion 8 is formed as a jacket construction in this exemplary embodiment and accordingly has a plurality of supporting struts 10 connected to one another like a framework. The supporting struts 10 or the portions of the supporting struts 10 which are associated with the underwater region 8a of the supporting portion 8 are arranged below the water surface 9. The supporting struts 10 or the portions of the supporting struts 10 which are associated with the above-water region 8b of the supporting portion 8 are arranged above the water surface 9.

The supporting struts 10 of the underwater region 8a and of the above-water region 8b of the supporting portion 8 are coated with a multi-layered protective coating 12. The connecting elements which connect the individual supporting struts 10 of the underwater region 8a and of the above-water region 8b of the supporting structure to one another are also coated with the multi-layered protective coating 12. The multi-layered protective coating 12 has a first adhesion promoter layer and a second polymer layer located above it. The polymer layer is substantially completely formed from polyurethane. Epoxy resin or adhesive can be used as the adhesion promoter. The individual layers of the multi-layered coating 12, i.e. the adhesion promoter layer and the polymer layer, can be applied with a layer thickness in the range of 1 mm to 5 mm.

The supporting struts 10 of the above-water region 8b are additionally coated with an outer paint layer 14. The outer paint layer is also applied above an additional adhesion promoter layer on the multilayer coating 12. The outer paint layer 14 has traffic-yellow coloured pigments, which are formed as inorganic coloured pigments. The coloured pigments always retain their optical colour effect under the action of ultraviolet radiation.

Figure 2 shows an exemplary embodiment of a multi-layered coating 12 on the surface of a supporting strut 10, which is formed as a steel pipe (not completely shown). The multi-layered protective coating 12 has two individual layers, namely a first lower adhesion promoter layer 18 and a second polymer layer 20 located above it. For example, epoxy resin or adhesive comes into consideration as the adhesion promoter. The polymer layer can be formed partially or completely from polyurethane, polyethylene, or polypropylene. Furthermore, the polymer layer 20 can contain plasticisers.

An outer paint layer 14 is applied on the multi-layered protective coating 12. The outer paint layer 14 has traffic-yellow coloured pigments, wherein the outer yellow paint layer retains its optical colour effect even under the action of ultraviolet radiation.

List of reference signs

	1	offshore supporting structure
	2a, 2b, 2c, 2d, 2e, 2f	fastening means
5	4	bed of a body of water
	6	receiving means
	8	supporting portion
	8a	underwater region
	8b	above-water region
10	9	water surface
	10	supporting struts
	12	multi-layered protective coating
	14	outer paint layer
	18	adhesion promoter
15	20	polymer layer

Patentkrav

1. Offshore-bærestruktur (1) til en vindmølle med
et eller flere fastgøringsmidler (2a, 2b, 2c, 2d, 2e, 2f) til
5 fastgøring af bærestrukturen (1) på havbunden (4),
en optagsanordning (6) til optag af et tårnskaft til vindmøllen
og
et bæreafsnit (8), som har et område under vand (8a) og et område
over vand (8b) og omfatter en eller flere bærestivere (10), idet
10 bærestiverne (10) forbinder optagsanordningen (6) med
fastgøringsmidlerne (2a, 2b, 2c, 2d, 2e, 2f),
idet en eller flere bærestivere (10) i området under vand (8a)
og en eller flere bærestivere (10) i området over vand (8b) i
det mindste afsnitsvis er belagt med en flerlaget
15 beskyttelsesbelægning (12), idet beskyttelsesbelægningen (12)
har i det mindste et polymerlag (20), fortrinsvis et
tokomponent-polymerlag (20),
idet polymerlaget (20) omfatter polyurethan eller i det
væsentlige er udført helt af polyurethan,
20 og idet der i området over vand (8b) i det mindste afsnitsvis
på den flerlagede beskyttelsesbelægning (12) er påført et ydre
laklag (14), idet det ydre laklag (14) har farvepigmenter.
2. Offshore-bærestruktur (1) ifølge krav 1,
25 kendetegnet ved, at en eller flere, fortrinsvis alle bærestivere
(10) i området under vand (8a), og/eller en eller flere,
fortrinsvis alle bærestivere (10) i området over vand (8b), på
deres udvendige flader og/eller i det væsentlige fuldstændigt
er belagt med den flerlagede beskyttelsesbelægning (12).
30
3. Offshore-bærestruktur (1) ifølge krav 2,
kendetegnet ved, at farvepigmenterne er uorganiske
farvepigmenter, som ved indvirkning af ultraviolet stråling
bibeholder sin optiske farvevirkning.
35
4. Offshore-bærestruktur (1) ifølge krav 2 eller 3,
kendetegnet ved, at farvepigmenterne er gule, navnlig
trafikgule.

5. Offshore-bærestruktur (1) ifølge et af de foregående krav, kendetegnet ved, at den flerlagede beskyttelsesbelægning (12) har et vedhæftningsmiddel (18), fortrinsvis to
5 vedhæftningsmidler (18).
6. Offshore-bærestruktur (1) ifølge et af de foregående krav, kendetegnet ved, at polymerlaget (20) har blødgørere.
- 10 7. Offshore-bærestruktur (1) ifølge et af de foregående krav, kendetegnet ved en eller flere korrosionsbeskyttelsesanordninger, som er udført til at yde aktiv katodisk korrosionsbeskyttelse.
- 15 8. Fremgangsmåde til fremstilling af en offshore-bærestruktur (1) til en vindmølle med trinnene:
- belægning af en eller flere bærestivere (10) i bærestrukturen (1) med en flerlagede beskyttelsesbelægning (12) ved at påføre, navnlig påsprøjte, i det mindste et polymerlag (20), fortrinsvis
20 et tokomponent-polymerlag, idet polymerlaget (20) omfatter polyurethan eller i det væsentlige er udført fuldstændigt af polyurethan,
- påføring af et ydre farvet laklag (14), navnlig et laklag (14), som har gule farvepigmenter, og/eller som ved indvirkning
25 af ultraviolet stråling bibeholder sin optiske farvevirkning, på beskyttelsesbelægningen (12), fortrinsvis før de forskellige bærestivere (10) forbindes med hinanden, og
- forbindelse af flere bærestivere (10) med hinanden, idet bærestiverne (10), før de forbindes indbyrdes, belægges med
30 den flerlagede beskyttelsesbelægning (12).
9. Fremgangsmåde ifølge krav 8, idet belægningen af den ene eller de flere bærestivere (10) i bærestrukturen (1) med den flerlagede beskyttelsesbelægning (12)
35 sker på en sådan måde, at bærestiverne (10) på deres udvendige flader og/eller i det væsentlige fuldstændigt belægges med den flerlagede beskyttelsesbelægning (12).

10. Fremgangsmåde ifølge krav 9,
endvidere omfattende trinnet:

- påføring af den flerlagede beskyttelsesbelægning (12) eller den flerlagede beskyttelsesbelægning (12) og det udvendige farvelag (14) på forbindelseselementer og/eller forbindelsesafsnit mellem indbyrdes forbundne bærestivere (10).

11. Fremgangsmåde ifølge et af kravene 8 til 10,
idet belægningen af en eller flere bærestivere (10) i
10 bærestrukturen (1) med den flerlagede beskyttelsesbelægning (12)
endvidere omfatter i det mindste et af følgende trin:
- påføring, navnlig påsprøjtning, af i det mindste et
vedhæftningsmiddel (18), fortrinsvis af to vedhæftningsmidler
(18).

- 15 12. Fremgangsmåde ifølge et af kravene 8 til 11,
idet polymerlaget (20) har blødgørere.

13. Fremgangsmåde ifølge et af kravene 8 til 12,
20 endvidere omfattende trinnene:
- påføring af den flerlagede beskyttelsesbelægning (12) eller den flerlagede beskyttelsesbelægning (12) og det udvendige farvede laklag (14) på en optagsanordning (6) til optag af et tårnskaft i vindmøllen; og
25 - forbindelse af den belagte optagsanordning (6) med en eller flere bærestivere (10).

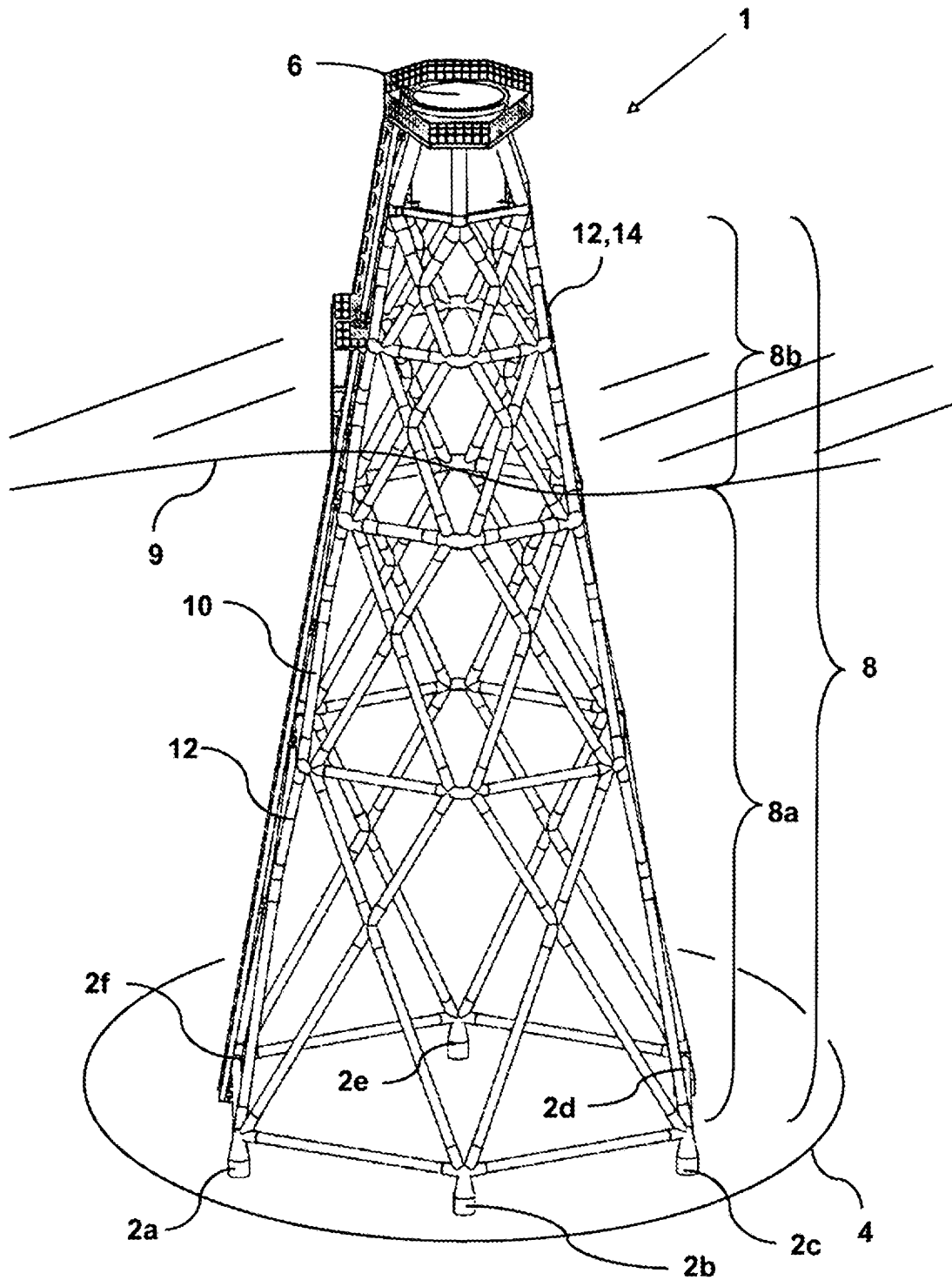


Fig. 1

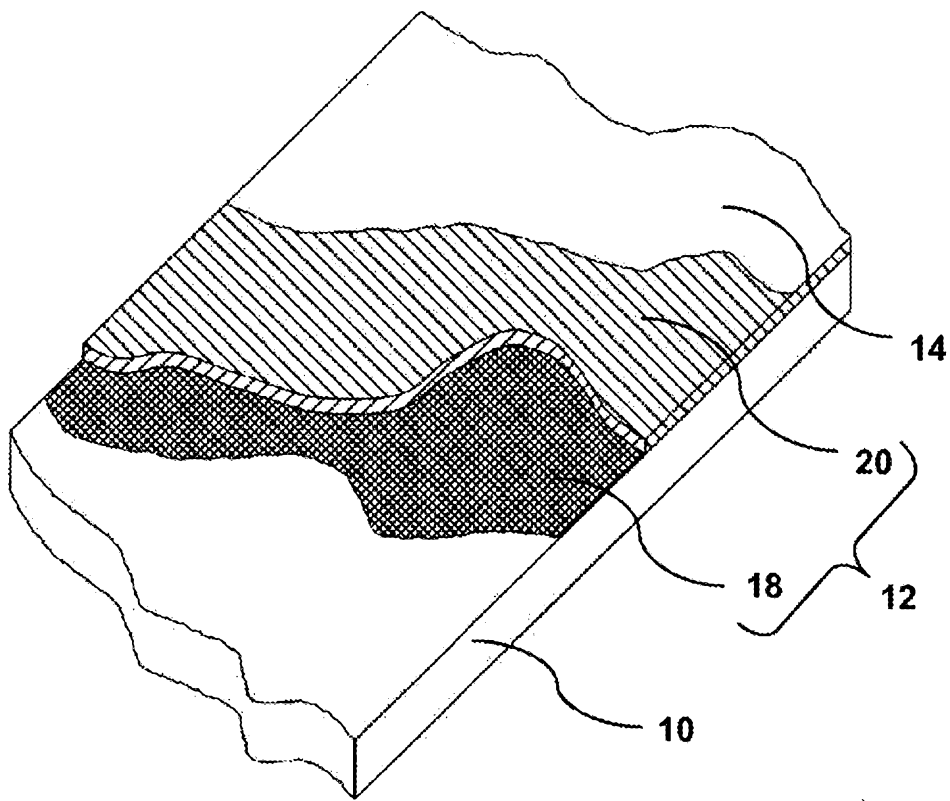


Fig. 2