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(54) **Depth buoy for maritime applications and process for making it**

(57) Depth float for maritime applications with floating thrust formed from a shaped body made up of a core (2) of carbon foam and an impermeable coating layer (3) arranged to cover the shaped body to avoid water infiltrations inside the carbon foam core (2).

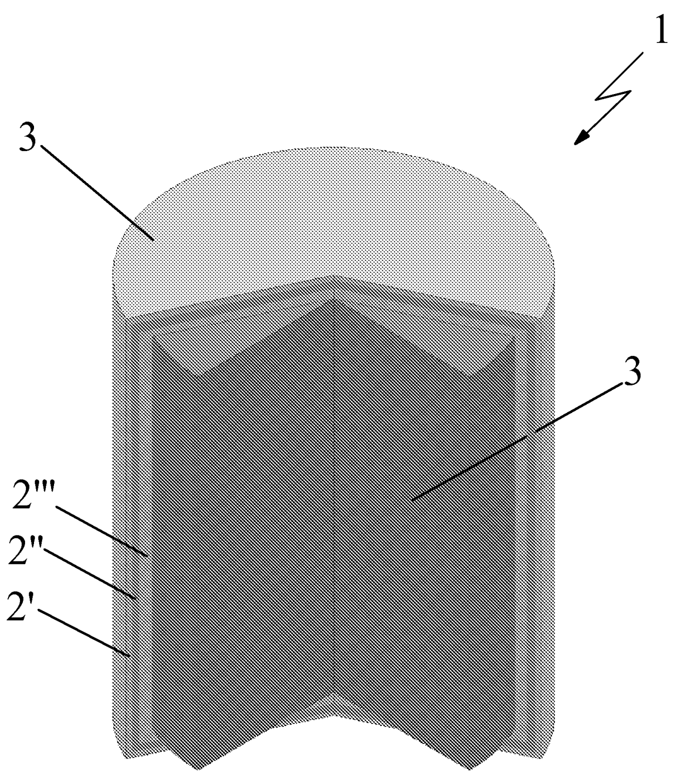

Fig. 1

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Description

Field of application

[0001] The present invention concerns a float for maritime applications and a process for making it.
[0002] The float concerned is intended to be advantageously used to make submarine applications in particular at great depths.

State of the art

[0003] Numerous solutions for floats are known on the market, which have the function of increasing the floating thrust - hereafter simply indicated as positive thrust - of the submarine apparatuses operating at certain depths below sea level.
[0004] Indeed, as is known submarine apparatuses can be gravitational or, like in the field of interest here, substantially neutral, i.e. positioned at the operative depth in order to be easily moved or held in the desired position. In order to achieve such a purpose floats can reach even substantial sizes and be connected together to make assemblies that are modular and/or of substantial size and of the most widely varying shapes according to the design requirements.
[0005] Floats are made differently according to the depth for which they are intended, i.e. according to the pressure range to which they can be subjected without undergoing variations in thrusting capacity due to water infiltrations or a decrease in volume.
[0006] The floats object of the present invention are intended for the market of floating systems suitable for being used in particular, but not only, at depths of over 1500 metres, i.e. with pressures of above 15 MPa.
[0007] The known solutions for floats that are intended for such depths are generally constructed by using "female" moulds.
The process consists of arranging spheres, known in the technical jargon of the field by the term "macro-spheres", in the mould and thereafter proceeding to fill the mould and fill in the gaps between the balls with resin or syntactic foam sometimes enriched with vitreous micro-spheres to lighten and/or strengthen the synthetic matrix.
The macro-spheres have a regular shape, are of different sizes and materials and characterised by their low weight/volume ratio: their purpose is to decrease the average density of the float by compensating for the higher values of the syntactic foam.
[0008] Some examples of floats of the type quoted above are described and illustrated in patents GB 2379681, US 5,937,031 and WO 00/75546.
[0009] In order to obtain floats made from materials with ever greater performance, i.e. characterised by an increasingly low density, further solutions for floats have more recently been developed, like for example the float described in patent WO 00/75546 that foresees the use of a plurality of hollow tubes closed at the ends and embedded inside a matrix of resin and micro-spheres.
[0010] The main drawback of the solutions known up to now that are present on the market is the fact that the manufacturing processes adopted up to now do not lend themselves to a preliminary testing of the mechanical and geometric characteristics of the product.
[0011] Moreover, it is not possible to guarantee *a priori* that the product perfectly adheres to the design data.
[0012] Only after the catalysation process of the syntactic foam has been completed and the float has been removed is it possible to check whether or not it meets the design data: in the negative case the product has to be declassed or even worse scrapped.
[0013] The drawbacks of the aforementioned process are the following:

1. chemical process for producing syntactic foam: components, times and methods vary according to temperature, pressure, humidity and characteristics of the mould;
2. macro-spheres are a non-industrial product: macro-spheres offer no guarantee in terms of homogeneous quality;
3.the deficiencies listed in the aforementioned points 1) and 2) must be applied in context amplifying the error;
4. the density of the floats thus obtained is not precise but an average between the density of the macro-spheres and of the syntactic foam: there are therefore substantial differences in the distribution of the density and therefore in the mechanical/physical characteristics that penalise the performance of the buoys and make it difficult to move them in 1: 1 scale.

[0014] For floats of substantial size for which it is not possible to perform true tests, it is, moreover, necessary to work by analogy by sinking a sample of syntactic foam in a test piece and subjecting it to the necessary tests with all of the uncertainty that this involves: it goes without saying that there is no unequivocalness and reciprocity in the behaviours of the float and of the test piece.
[0015] Moreover, the different possible distributions of the macro-spheres, which often differ from the design in size and density, may, when the float is finished, lead to an end weight that differs, sometimes by a great deal, from the design weight.

Presentation of the invention

[0016] In this situation, the essential purpose of the present invention is therefore to eliminate the drawbacks of the aforementioned known solutions, by providing a depth float for maritime applications, of excellent quality and operatively totally reliable.
[0017] Another purpose of the present finding is to make a process for producing a depth float for maritime applications that is simple to make and that can be subjected to preliminary tests before the production process

is complete.

[0018] A further purpose of the present finding is to make a process for making floats that lends itself to making product of the desired shape without needing questionable seal tests obtained by analogy.

Brief description of the drawings

[0019] The technical characteristics of the finding, according to the aforementioned purposes, can be clearly seen from the content of the claims displayed below and the advantages thereof shall become clearer in the following detailed description, made with reference to the attached drawings, which represent purely a non-limiting example embodiment, in which:

FIG. 1 shows a schematic section view of a float object of the present invention.

Detailed description of a preferred example embodiment

[0020] With reference to the attached drawings the depth float for maritime applications, object of the present invention, has been wholly indicated with 1.

[0021] It can be used for any maritime application that requires the use of a body equipped with a positive thrust once immersed in water.

[0022] According to the idea forming the basis of the present invention the float (fig.1) is formed from a shaped body integrally made up of a core 2 (hereafter just core) of carbon foam and is entirely protected by a skin 3, i.e. by an impermeable coating layer (hereafter referred to as just skin or coating) suitable for avoiding water infiltrations inside the carbon foam.

[0023] By the term carbon foam hereafter we mean material commonly indicated with the technical expressions "carbon foam, graphitic foam, lightened carbon".

[0024] Carbon foam is therefore already a product that is identifiable and available on the market that is widely used for example to make fire-retardant walls for making refractory walls.

[0025] According to the present invention, the geometric barycentre of the float substantially coincides with its centre of mass since the density of the carbon foam core is uniform.

[0026] Unlike in known floats using micro-spheres or macro-spheres immersed in a matrix of resin or plastic foam the distribution of the spheres cannot guarantee (and actually never corresponds to) coinciding of the barycentre with the centre of mass. Indeed, the areas of the float broken up by variously shaped walls defining articulated shapes are not suitable for receiving the same number of micro or macro-spheres with respect to the volumes farthest from the walls. Therefore, the position of the centre of mass in current floats depends upon the shape of the float itself.

[0027] Moreover, advantageously, the float object of the present invention has a precisely uniform density in the entire volume of its core so that upon taking directrices that cross the volume of the float it is possible to note a uniform and constant density on them.

[0028] It should also be specified that the float object of the present invention has a carbon foam core that is structural for mechanical strength whereas the micro or macro-spheres used in the type of depth float considered are just fillers unsuitable by themselves for defining the shape and mechanical support structure of the float.

[0029] The carbon foam can preferably be with open cells for optimal sticking of the coating or with closed cells for optimal impermeability.

[0030] The solution with closed cells is certainly the preferable one and is strictly necessary where it is required for the float the keep its designed positive floating thrust unchanged, avoiding any insertion of water inside of it.

[0031] In greater detail, the solution with open cells can be used to make outer covers of deep pipes, in order both to resist abrasion and above all in order to thermally insulate the extraction liquid in the predetermined thermal conditions.

[0032] In order to avoid the skin fracturing into small cracks allowing the water free to enter inside the foam, the skin 3 itself is in any case susceptible of deforming under the pressure of the water to stick tightly with the carbon foam 2.

[0033] For this purpose, the coating layer 3, in accordance with the preferred embodiment of the present invention, is an elastomeric polyurethane and in particular consists of one or more components or mixtures of components selected from the group:

- isocyanate
- polyol (alcohol)

[0034] Otherwise, polyethylene or silicone products can also be used for the outer coating 3.

[0035] Also forming the object of the present invention is a process for producing the float of the type described.

[0036] Hereafter, for the sake of simplicity of explanation we shall refer to the same nomenclature introduced up to now, although it should be understood that the present process can also create floats with different characteristics to those considered above.

[0037] The process object of the present invention begins with the provision of a block of carbon foam.

[0038] The carbon foam is generally obtained from a controlled heating of pulverised carbon in a mould in inert atmosphere.

[0039] It is also possible to use bitumen, anthracite, lignite (even mixed together) provided that they are bituminous, instead of the carbon or mixed together with the carbon.

[0040] The sequence for producing the carbon foam is usually the following:

- progressive increase in temperature of the pulverised carbon, contained in a mould in inert atmosphere, at about 300-700 °C;

- the pulverised carbon, contained in a mould in inert atmosphere, is kept (cooking) at about 300-700 °C from 1 to 12 hours in order to form a structural product with carbonaceous matrix;
- the aforementioned structural product, contained in a mould in inert atmosphere, is cooled to 100 °C with ratios of under 10°C/minute to prevent breaking as a consequence of thermal shock;
- the aforementioned product contained in a mould in inert atmosphere is then taken to room temperature from the aforementioned 100 °C;
- the inert atmosphere can be obtained by injecting gas such as nitrogen, helium, argon, CO_2,...at pressures not exceeding 3.5 MPa

[0041] Variations in terms of heating speed, cooking time, cooling speed, pressure inside the mould, type of inert gas in the mould result in different mechanical and physical characteristics of the carbon foam obtained from the process described above.

[0042] The production process of the carbon foam briefly described above in an embodiment is *per sé* known to the man skilled in the art and for this reason it has not been considered in detail.

[0043] The production process of the carbon foam is also already known for making both structures with closed cell (generally obtained with quicker cooling) and structures with closed cell.

[0044] Detailed information on the processes for making carbon foam, to be considered as included for reference with the present text, are contained in patents WO 2005/073128; WO 03/024866; WO 01/40414; WO 2006/105493; US 2003/0071384 and in the articles: 1) "Strength enhancement and application development of carbon foam for thermal protection systems" by Christopher Duston; dr. Steve Seghi; mr. Roland Watts; 2) "Case studies of carbon foam tooling" by Rowe Matthew m.; Guth Richard Andrew ; Merriman Douglas j. ; S.A.M.P.E. journal issn 0091-1062 2005, vol. 41, n4, pp. 63-71 SAMPE, Covina,ca, etats-unis (1973) (revue); 3) «Low temperature behavior of carbon fiber / epoxy composites: matrix and fiber influences on cryogenic microcracking "John F. Timmerman, Matthew S. Tillman, Brian S. Hayes, and James C. Seferis university of Washington department of chemical engineering polymeric composites laboratory Seattle, Washington 98195 SAMPE 2001 - Long Beach, ca may 6 - 10, 2001.

[0045] Also forming the object of the present invention is a process for producing floats that foresees the steps described hereafter.

[0046] From the blocks of carbon foam identified for the construction of floats a significant number of test pieces are taken upon which the necessary tests will be performed in particular appropriate hyperbaric tests.

[0047] In the case of a negative outcome the material shall not be used and another batch will be selected.

[0048] In the case of a positive outcome the block will be mechanically worked to obtain the desired shape.

[0049] In order to obtain special shapes and/or sizes it is possible to join many blocks by gluing both before and after processing.

[0050] The worked block thus obtained will be subjected to size testing.

[0051] In the case of a negative outcome the worked block will have to be reworked as a whole or partially with replacement, also through gluing, of the parts not matching the other blocks of material.

[0052] In the case of a positive outcome the material can be reinforced locally or totally with carbon fibre, kevlar or glass in order to allow particular types of anchoring.

[0053] At the end of the aforementioned processes the block is ready to be protected by the covering skin.

[0054] The application process can be carried out by spraying.

[0055] The skin can be applied in one or more layers according to the type of use.

[0056] The gluing process of the blocks constituting the float can also be carried out after the coating process: this results in greater protection of the individual components.

[0057] Holes, grooves, lifting and fixing eyebolts, which can all be coated with the aforementioned coating, can be made on the shaped body 2 of the float through mechanical processing, gluing or mechanical inserts.

[0058] Such a coating layer 3 performs the functions of waterproofing quoted previously and of protection from knocks, abrasions and aggressive agent both in and out of the water.

[0059] The float 1 according to the invention can be industrially produced faster than known floats from the state of the art, since it does not foresee either the use or the construction of dedicated moulds but requires just the use of machines with numerical control. The process according to the invention allows floats to be obtained in the desired shapes and sizes, does not require testing of its carbon foam core once produced to check the resistance to the hydrostatic pressure at which it is intended to work (for example with samples that are often unable to reproduce the true scale conditions), give that it is produced with a material already intrinsically equipped with such a characteristic and in any case testable *a priori.*

[0060] The application of one or more layers of protective skin 3 protects the float 1 from wear, from the penetration of water and from surface abrasion. The layers of skin can be of different colours (e.g.: the first yellow, the second red, the third black...) in order to allow the colour of the underlying layer (e.g. red) to be seen in the case of abrasion of a surface layer (e.g. yellow): this, for the operator, constitutes an indicator of damage.

[0061] In the example of the figure three different layers 3'; 3" and 3"' have for example been foreseen.

[0062] The finding thus conceived therefore accomplishes the predetermined purposes.

[0063] Of course, in its practical embodiment it can also assume different shapes and configurations from the one illustrated above without for this reason departing from the present scope of protection.

[0064] Moreover, all of the details can be replace by technically equivalent elements and the sizes, shapes and materials used can be whatever according to needs.

Claims

1. Depth float for maritime applications which possesses a positive floating thrust **characterised in that** it comprises a shaped body made up of a core (2) of carbon foam, and an impermeable coating layer (3) arranged to cover said shaped body to avoid water infiltrations inside the carbon foam core (2); said float also being **characterised in that** the geometric barycentre and the centre of mass of its core substantially coincide.

2. Depth float according to claim 1, **characterised in that** said core defines the shape of said float and is responsible for the mechanical and hydrostatic resistance of the float.

3. Depth float according to claim 1, **characterised in that** said core has a precisely uniform density in its entire volume.

4. Depth float according to claim 1, **characterised in that** said coating layer is made from elastomeric polyurethane.

5. Depth float according to claim 1, **characterised in that** said elastomeric polyurethane is polyethylene or a silicone base comprising one or more components selected from the group:

   - isocyanate
   - polyol

6. Depth float according to one or more of the previous claims, **characterised in that** said coating layer is susceptible of deforming in a yielding manner under the pressure of the water to stick tightly with the carbon foam.

7. Depth float according to claim 1, **characterised in that** said carbon foam has open cells for optimal sticking of the coating.

8. Depth float according to claim 1, **characterised in that** said carbon foam has closed cells for optimal impermeability.

9. Depth float according to claim 1, **characterised in that** said carbon foam has a density within the range 0,02-0,80 g/cm^3.

10. Depth float according to claim 5, wherein the covering skin consists of one or more layers of protection from wear, liquids and abrasions, in particular with different colours.

11. Process for making depth floats for maritime applications of the type equipped with positive thrust, **characterised in that** it comprises:

    - a step of making a shaped body consisting of carbon foam;
    - a step of covering said shaped body with an impermeable coating layer suitable for avoiding water infiltrations inside the carbon foam of said shaped body.

12. Process according to claim 11, **characterised in that** said shaped body is made from a block of carbon foam, in particular through mechanical processing.

13. Process according to claim 11, **characterised in that** said shaped body is obtained through gluing of many blocks of carbon foam, in particular obtained as specified in claim 12.

14. Process according to claim 13, **characterised in that** said step of coating said shaped body is obtained by coating the individual blocks successively glued or else by coating the shaped body formed from previously glued blocks.

15. Process according to claim 11, **characterised in that** dedicated holes and grooves are made on said shaped body through mechanical processing by lifting and/or fixing, which can also be covered by the coating skin.

16. Process according to claim 11, **characterised in that** suitable lifting and/or fixing eyebolts are applied on said shaped body through mechanical connections or gluing.

17. Process according to claim 11, **characterised in that** said coating layer is applied by spraying directly on said shaped body.

18. Process according to claim 11, **characterised in that** it is possible to locally reinforce the carbon foam core through application of carbon fibre, kevlar, or fibreglass.

19. Process according to claim 11, **characterised in that** said step of making the shaped body from carbon foam is obtained from heating, cooking and cooling of carbon and/or bitumen and/or anthracite and/or lignite, provided that it is bituminous, pulverised in a mould kept in inert atmosphere: heating and cooling speed, cooking time, type of inert gas and

pressures of the processes inside the mould are selected according to the mechanical and physical characteristics of the carbon foam to be obtained.

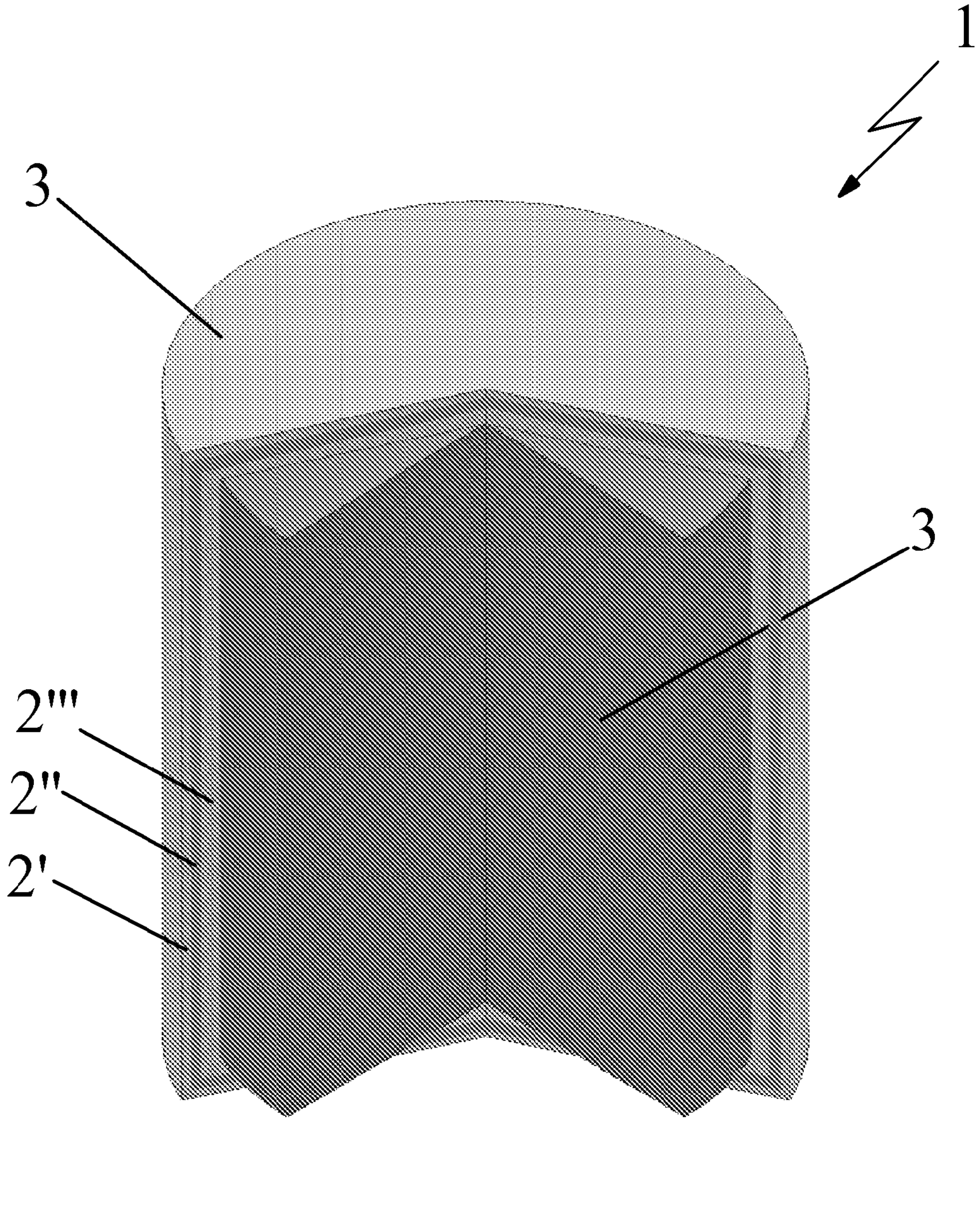

Fig. 1

REFERENCES CITED IN THE DESCRIPTION

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