

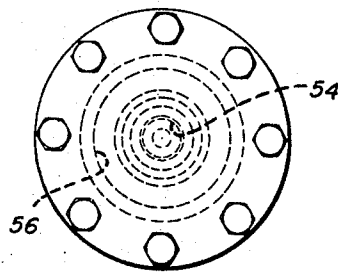
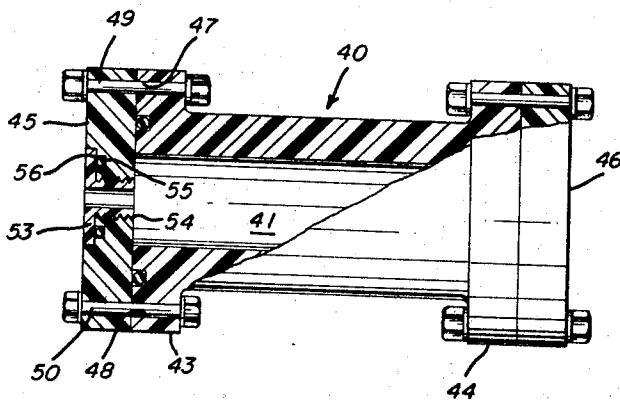
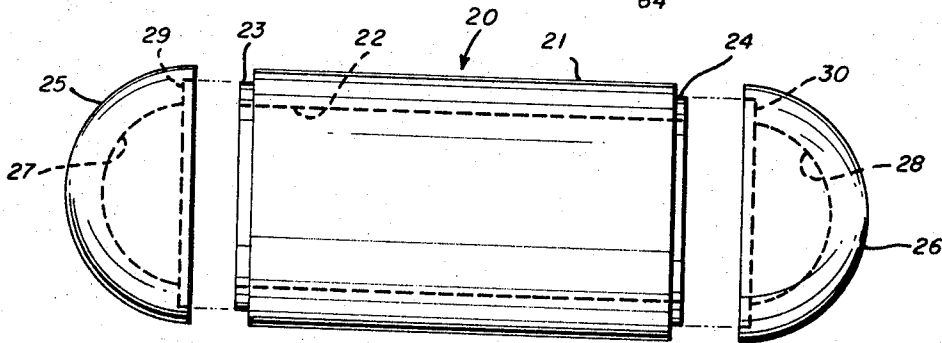
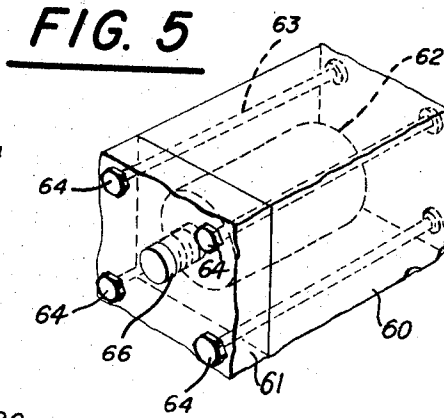
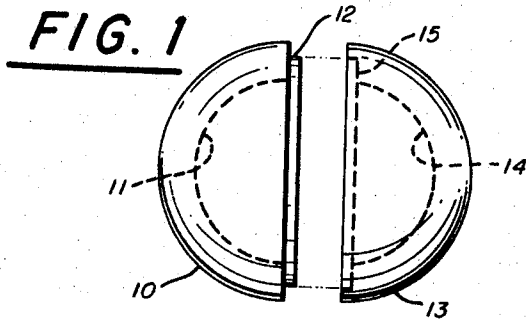
April 8, 1969

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3,436,775

DEEP SUBMERSIBLE INSTRUMENTATION PACKAGE ASSEMBLY

Filed Dec. 28, 1966



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DEEP SUBMERSIBLE INSTRUMENTATION PACKAGE ASSEMBLY

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Filed Dec. 28, 1966, Ser. No. 605,516

Int. Cl. B63b 21/52

U.S. Cl. 9—8

18 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure is concerned with an improved deep submersible instrumentation package assembly comprising a body member and one or more cover members formed of a particular type of material to provide appropriate protection for instrumentation under the severe environmental conditions encountered in deep submergence oceanographic work, for instance. The body and cover members of the assembly are preferably fabricated of a syntactic foam or comparable material and the buoyant bulk of the body and cover members relative to the weight of the entire assembly, including the enclosed instrument, is so chosen and predetermined as to provide a desired degree of aggregate buoyancy in the medium where the assembly is to be submerged. Accordingly, the assembly may be rendered positively, negatively or neutrally buoyant in a predesigned degree as desired.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Background of the invention

In much of the presently existing oceanographic instrumentation packaging metallic materials are used because of their structural strength in resisting the extremely high pressures encountered in the deep ocean environment. These heavy packaging assemblies are often non-buoyant and if not inherently corrosion resistant by reason of the type of the metallic material employed, must be treated for corrosion protection by appropriate processing. Typical materials employed may be stainless steel, brass, aluminum, titanium, etc. Some processes which are employed to protect these materials are anodizing, passivating, painting, etc. Such processing of instrumentation packaging adds to the cost and difficulty of fabrication. Additionally, in the forming and fabrication of such deep submersible instrumentation packaging assemblies, extensive facilities must be employed including lathes, milling machines, borers, etc. which have extensive capabilities in working these different types of metals. Those knowledgeable in the art will recognize readily that some of the shortcomings and disadvantages of prior art types of deep submersible instrumentation packaging are that they are often non-buoyant, require corrosion protection, and are difficult to fabricate in addition to requiring relatively expensive metal working machinery.

Moreover, since most existing oceanographic deep submersible instrumentation packaging is non-buoyant, it places a severe limitation upon the amount of instrumentation which may be carried by deep submersible vessels. Such deep submersible vessels usually have a limited capacity for weight which may be added by reason of the placement and addition of instrumentation outside its hull. If the limitation of weight outside the hull is exceeded by adding more instrumentation than can be accommodated within critical specifications, the operative performance and characteristics of the vessel may be detrimentally effected.

Accordingly, it is an object of the present invention to provide an improved deep submersible instrumentation package assembly which overcomes many of the cited disadvantages and limitations of known prior art instrumentation packaging.

It is also a major object of the present invention to provide a deep submersible instrument package assembly which affords adequate protection for the enclosed instrumentation against the severe environmental conditions as encountered in oceanographic work and is also adaptable to provide a desired degree of predetermined positive, negative or neutral buoyancy.

Another most important object of the present invention is to provide an improved deep submersible instrument packaging assembly including the advantages of the foregoing objects and also being fabricated of a material which obviates the necessity for processing to protect against corrosion effects of the severe oceanographic environment particularly in deep submergence work.

Summary of the invention

The present invention may preferably comprise a deep submersible instrument packaging assembly fabricated of syntactic foam material and including a body member and at least one cover member. The cover member is configured to fit on the body member for enclosing the instrument. Appropriate means are provided for securing the cover member in pressure contact with the body member for sealing the enclosed instrument against outside deep submergence pressures; the body and cover members are of selectively determined buoyant bulk relative to the weight of the assembly including the enclosed instrument for providing a desired predetermined degree of aggregate buoyancy in the medium where the entire assembly is to be submerged. This buoyancy may be predesigned to provide positive, negative or neutral aggregate buoyancy as desired.

As is well known in the art syntactic foam may be selected providing adequate strength for deep submergence work in excess of 20,000 pounds per square inch pressure. Moreover, syntactic foam fabricated of micro-miniature glass spheres bonded in a plastic matrix is virtually impervious to corrosion effects even in the severe deep oceanographic environment. Additionally, as will be readily understood and appreciated by those skilled in the art, the aggregate buoyancy of the instrumentation package assembly may be precalculated to provide a desired degree of buoyancy even in the event that the interior of the assembly becomes accidentally flooded.

Another significant advantage of the present invention is the fact that syntactic foam materials may be readily and accurately machined by the use of wood-working tools, obviating the necessity for a wide variety of high precision and expensive metal working machinery as was necessitated by many prior art deep submersible instrumentation packaging assemblies. If desired, syntactic foam can be readily bonded by the use of appropriate chemical bonding agents and may also be drilled, tapped and threaded to receive bolts, screws, or studs.

These and other objects, advantages and features of the present invention will be more fully understood from the following description of several embodiments together with the drawings and the scope of the invention will be pointed out more particularly in the appended claims.

Brief description of the drawings

In the drawings:

FIG. 1 is an illustration of an embodiment of the present invention comprising a hemispherically-shaped body member and cover member;

FIG. 2 is an illustration of a variant embodiment of the present invention comprising a substantially cylindri-

3

cal body member and two hemispherically shaped cover members;

FIG. 3 is a partially cross-sectional view of a preferred embodiment of the present invention comprising a body member which is substantially cylindrical in configuration having flanges extending from either end and adapted to fit substantially planar or flat cover members;

FIG. 4 is an end view of the embodiment illustrated in FIG. 3 showing the manner in which a fitting may be sealed in one of the members of the assembly for providing communication with its interior; and

FIG. 5 is a perspective view of another preferred embodiment of the present invention.

Description of the preferred embodiments

FIG. 1 illustrates an embodiment of the present invention which comprises a cover member and a body member of substantially hemispherical configuration. A body member 10 comprises a hollowed out sphere as indicated by the interior wall outline shown by the dash lines at 11. The body member 10 is provided with an embossed portion 12 of a lesser diameter than that of the outside diameter of the body member 10. The cover member 13 may be of the same size and shape as the body member 10. The cover member 13 may be of the same size and shape as the body member 10 i.e., substantially hemispherical, and may also have a hollowed out portion providing a hemispherical wall, the interior limits of which are indicated by the dash line at 14.

A recessed portion dimensioned and configured to fit in matched relationship with the embossed portion 12 is provided within the cover member 13 as shown by the dash lines at 15. Accordingly, the body member 10 receives the cover member 13 to enclose an instrument therein. Appropriate means may be provided for securing the cover member 13 to the body member 11. Such means may comprise an appropriate bonding plastic or similar bonding agent which may be applied to the matched surfaces of the body member 10 and the cover member 13 to seal the hollow interior against the deep submergence pressures of the outside environment. Alternatively, other suitable means such as bolts received into threaded and fitted recesses may be employed together with O-rings or sealing means to protect the interior cavity of the instrumentation package assembly against the severe deep submergence outside environment.

It is to be understood that the body member 10 and the cover member 13 are both formed of syntactic foam material; a wide variety of such materials are currently available and have the necessary properties as required by the concept of the present invention. The buoyant bulk of such material may be readily calculated by the relationship of the thickness of the wall from the outside of the body member 10 to its interior wall enclosure 11 and the outside diameter of the cover member 13 to the interior of the enclosure as shown at 14. These factors together with the overall dimensions and configurations of the instrumentation package assembly and the weight of the instrument which it is desired to enclose and protect therein will provide the means of calculating, with a high degree of accuracy, the relative aggregate buoyancy of the assembly including the enclosed instrument as will result in the medium where the entire assembly is to be submerged.

An appropriate fitting may be sealed into one of the members of the assembly such as that shown in FIG. 1 in the spherical configuration so as to provide a means of communication from the outside of the package assembly to the instrument enclosed therein for purposes of continually recording or determining the data indicated by the enclosed instrument, for example. The manner in which such fitting may be sealed into a deep submersible instrumentation packaging assembly of the present invention will be described more fully as it is incorporated in another of the embodiments of the invention.

4

FIG. 2 illustrates an embodiment of the present invention wherein the body member comprises a substantially cylindrical form of syntactic foam having a hollow portion to receive an instrument therein. Two substantially identical hemispherical cover members are provided to enclose the instrument and seal it against environmental conditions of deep submergence oceanographic exploration. As shown in FIG. 2 the body member 20 is comprised of a substantially cylindrical form of syntactic foam selected for its desirable properties in relation to the environment in which it is to be used. It has a wall thickness between the outside diameter as indicated at 20 and the inside diameter as indicated by the dash lines shown at 22. At either end of the body member 20, an embossed annular portion is shown as indicated at 23 and 24. The embossed portions of the body member 20 as shown at 23 and 24 are of a lesser diameter than the outside diameter as indicated at 21 and extend from the end of the body member 20 by an approximately equal amount. The two substantially identical cover members 25 and 26 are provided as illustrated in FIG. 2 and are of hemispherical form. Hemispherical cover members 25 and 26 may also be hollowed out to provide a wall section having interior diameters as indicated at 27 and 28, respectively. Additionally, the cover members 25 and 26 each has a recessed circularly-formed portion as indicated at 29 and 30 which is configured and dimensioned to tightly receive the embossed sections 23 and 24, respectively, of the body member 20.

As was described in FIG. 1, the embodiment of FIG. 2 may also employ a bonding agent such as appropriate plastic material to bond the two cover members 25 and 26 to the body member 20 and seal the enclosed instrument against severe environmental conditions of deep ocean exploration. Similarly, as was explained in connection with the embodiment of FIG. 1, the buoyant bulk of the syntactic foam material which is employed to fabricate the finished, formed assembly comprised of the body member 20 and the two cover members 25 and 26 may be precalculated and predetermined so as to provide an aggregate buoyancy which is either positive, neutral or negative as may be desired.

Moreover, such buoyancy may also be calculated so that the entire assembly including the enclosed instrument is slightly positively buoyant even though its interior may become flooded; this provides a most important feature in the aspect of the present invention by reason of which instrumentation enclosed in the improved deep submersible instrumentation packaging assembly of the present invention is, in effect, "self recovering." The assembly may be made to provide a desired degree of positive buoyancy regardless of the fact that the interior becomes accidentally or unexpectedly flooded.

FIGS. 3 and 4 illustrate yet another preferred embodiment of the present invention which comprises a body member substantially cylindrical in configuration, having a hollow interior for receiving and enclosing an instrument therein. The assembly is completed by two cover members, one on each end of the body member, which are configured and dimensioned to match with flanges extending from the body member; in the particular configuration illustrated, the cover members are secured to the body members by a plurality of bolts passing through the matched flange portions of the body member and the cover members in a specific manner which will be described more fully hereinafter.

As shown in FIG. 3, a body member 40 is substantially cylindrical in form and has a hollow interior 41 extending from the cylindrical interior walls as shown at 42. At either end of the body member 40, flanges extend annularly in a substantially cylindrical configuration as shown at 43 and 44. Flat, circular, planar covers are provided at each end of body member 40 as indicated at 45 and 46. The end covers 45 and 46 are dimensioned and configured to fit over the flanges 43 and 44. A plurality of aligned spaced apertures are provided in the

5

flanges 43 and 44 to match with aligned spaced apertures in the cover members 45 and 46, respectively.

The manner in which such spaced apertures are positioned on the cover member 45 may perhaps be better seen as illustrated in FIG. 4. The apertures as indicated at 47 and 48 of FIG. 3 are so dimensioned relative to bolts or studs 49 and 50, that the bolts or studs or other appropriate securing means will be received snugly but yet allow for the seepage of fluid therethrough under extreme pressures of deep submergence environmental conditions. Accordingly, no strain or undue stress is placed on the syntactic foam material of which the body member 40 and the cover members 45 and 46 are fabricated.

It has been found that if a bolt or screw is received in a threaded hole in the syntactic foam, it is likely that a small amount of trapped, substantially atmospheric pressure may be formed at the lower end of the tapped hole into which the stud or bolt or screw is received. Further, under the extreme pressures of deep submergence environmental conditions, the entrapped air at atmospheric pressure creates such an extreme differential of pressures with respect to the outside fluid pressures, that cracks, fissures, or similar weaknesses may develop in the syntactic foam material of the deep submersible instrumentation packaging assembly.

Thus, it is most important in the concept of the present invention that the securing means employed to seal the cover member to the body member in pressure contact be such that it does not allow any entrapped air or similar voids to be formed. The problem of fissures, cracks, or other similar weaknesses developing by the creation of severe or extreme pressure differentials may be averted as taught by the concept of the present invention.

To further insure the sealed enclosure of an instrument in the deep submersible instrumentation package assembly of FIG. 3, an O-ring may be positioned in a recess such as that shown at 51 annularly formed on the flange face of the body member 40. The O-ring 52 is thus compressed under sealing pressure between the body member 40 and the cover member 45 by the securing means comprising the multiplicity of bolts 50. Similar O-ring means may be employed at the opposite end of the opposite end of the instrumentation package assembly to secure the desired pressure sealed contact between the cover member 46 and the body member 40.

In order to provide communication with the instrumentation enclosed and sealed within the deep submersible instrumentation package assembly, a sealed fitting such as that illustrated at 53 may be employed. The cover member 45 may be bored and tapped to provide threads as shown at 54 to receive the fitting 53 in threaded engagement. An annular recess 55 is provided disposed about the threaded aperture so that sealed contact may be provided by an O-ring 56 received in the recess 55 and compressed by the fitting 53. In this manner an electrical or other type of connection may be made to the instrumentation contained within the deep submersible instrumentation package assembly so that continuous reading may be taken by the instrumentation and recorded or observed as desired throughout the deep submergence exploration of the vessel on which the instrumentation assembly is supported.

FIG. 5 is a perspective drawing illustrating another preferred embodiment of the present invention. In the particular embodiment illustrated in FIG. 5 a body member is shown generally at 60 and comprises a substantially rectangular configuration. The body member 60, in accordance with the teaching and concept of the present invention, may be designed as to an approximate required size and shape by being sawn to the approximated outside dimensions through the use of a band saw or similar woodworking machinery. It is important to note that to avail of one of the more significant advantages of the present inventive concept, the outside dimensions and configuration of the instrumentation packaging

6

need only be approximated to produce an approximation of the desired degree of neutral, positive or negative buoyancy, preferably slightly more buoyant than is desired in the final assembly. Accordingly, the body member 60 of the embodiment of the present invention illustrated in FIG. 5 may be shaped from a solid block of appropriately chosen syntactic foam material. The solid block may also include the cover member 61 as an integral part of the initially roughly-shaped and dimensioned block of solid syntactic foam material. As a second step the cover member 61 may then be separated from the solid block of syntactic foam material so that it has the same outside dimensions as the body member 60. The body member 60 may then be machined internally so as to provide a cavity as generally indicated at 62.

The cavity 62 provides a recess dimensioned and configured to receive the particular instrumentation for which the packaging assembly of FIG. 5 is designed. The body member 60 and cover member 61 are then drilled to receive a securing means for fastening the cover member 61 to the body member 60 in pressure contact to seal out the high pressures encountered in deep submergence exploration. Alternatively, the plurality of holes may be drilled before the cover member 61 is separated from the body member 60.

An appropriate securing means comprising a plurality of rods 63 or studs may be passed through the aligned holes drilled in the body member 60 and the cover member 61 with nuts 64 secured to either end of the plurality of rods 63. Thus, the cover member 61 and body member 60 may be drawn tightly together in pressure contact preferably with an O-ring as shown by the dash outlines indicated at 65 to seal out the extremely high pressures encountered in the severe environmental conditions of deep submergence oceanographic exploration. As an alternate securing means, threaded studs may be secured in the body member to align with holes in the cover member 61, or the members may be bonded in sealed contact.

An appropriate fitting 66 is secured in cover member 61 in a manner similar to that explained in connection with the embodiment illustrated in FIGS. 3 and 4 so as to afford pressure-tight communication from the outside of the instrumentation packaging assembly to the interior cavity 62 where the instrument is contained and received.

It will be apparent to those skilled in the art that the embodiment of FIG. 5 may be adapted to employ cover members similar to those shown at 61 at either end of the body member 60, and generally in the manner of the configuration illustrated in FIGS. 3 and 4; moreover, a flanged configuration of body member may be employed as shown in FIGS. 3 and 4, but adapted to the particular teaching and advantages to be realized by the method of fabrication disclosed and described in connection with the embodiment illustrated in FIG. 5.

In accordance with the teaching and concept of the inventors, the roughly approximated instrumentation package assembly may be fitted with the plurality of securing means, the cover fitting, and the instrument which it is to enclose and protect and thereafter be tested to determine its precise degree of buoyancy. The concept of the present invention teaches that the precise and final degree of buoyancy may be arrived at by reducing excess bulk from the outside of the body member 60 and the cover member 61 to produce the exact degree of buoyancy, whether it be neutral, positive or negative. Accordingly, it is desirable that the roughly cut initial configuration such as the block shape shown in the configuration of FIG. 5 include some measure of extra bulk. Thus, in the rectangular configuration with a substantially circular cavity as shown in FIG. 5, a considerable amount of excess bulk is incorporated in the configuration so that any amount of which, within reasonable limits, may be removed to produce the exact degree of buoyancy desired. This reduction and precise adjustment of the buoyancy of

the complete assembly may be accomplished by use of relatively uncomplicated hand tools of woodworking type. This feature and advantage, as afforded by the choice of materials and the teaching of the present invention is, of course, equally applicable to other variant configurations in addition to the substantially rectangular configuration illustrated by FIG. 5.

Further, the concept of the present invention does not necessarily require that the cover members be comprised of syntactic foam material. It will be appreciated by those knowledgeable in the art that the teaching and concept of the present invention is equally applicable and may be readily embodied in assemblies which comprise a syntactic foam material body member and one or more metallic or other types of cover members wherein the aggregate bulk and buoyancy of the entire assembly is predetermined, designed and finally adjusted in accordance with the advantageous precepts of the present invention.

From the foregoing description of several embodiments of the present invention it will be apparent to those knowledgeable in the art that the present concept of a deep submersible instrumentation package assembly fabricated as taught by the concept of the present invention will provide the advantages of:

(1) A waterproof pressure sealed and corrosion resistant unit.

(2) An assembly which may be predetermined to have an aggregate positive, neutral or negative buoyancy at the discretion of the designer of the package.

(3) An assembly which may be used "wet," i.e., in situ, outside a deep submersible vessel without effecting or detracting from the performance and operation of the vessel by reason of changing its buoyancy.

(4) An assembly which may be recovered without additional floatation when released underwater.

(5) An assembly which may be of any desired geometric shape.

(6) An assembly which may be fabricated or modified by the use of unconventional woodworking tools rather than special complex metal working machinery.

These advantages provide highly desirable results in that the selective buoyancy as predetermined, provides an increased instrumentation capacity for deep submergence vessels. Additionally, the aggregate buoyancy of an assembly fabricated and designed according to the concept of the present invention may be made to be slightly positive so that the deep submersible instrumentation package assembly is in effect self-recovering when it is intentionally or unintentionally released at great depths.

Another advantage to the use of syntactic foam type materials is that such foam, while having all the desirable strength properties to withstand extremely high pressures in deep oceanographic environments, is also inherently corrosion resistant. Such corrosion resistance is a property of the material itself and thus does not require a treatment or chemical processing to effect the desired degree of resistance to corrosive effects as encountered particularly in salt water.

Yet another advantage of the present invention is that the assembly may be either a wet or dry internal type as desired and predesigned. Further, a deep submersible instrumentation package assembly fabricated in accordance with the teaching of the present invention for normally dry internal operation, may be intentionally designed to provide sufficient positive buoyancy for self recovery by return to the surface if accidentally flooded internally.

Another advantage of the present invention is that the syntactic type foam materials may be adapted to a great number of techniques for securing the body member, for instance, to the cover member such as chemical plastic bonding, screwing, bolting and clamping. This eliminates the welding, stress relieving, and heat treatment which were common to many prior art metal instrumentation packaging assemblies.

A further advantage of the present invention is that the type of syntactic foam material which is preferably

employed, makes field modifications in the instrumentation packaging assembly feasible by the use of simple woodworking tools; this was not possible with the prior art such as metal instrumentation packaging assemblies employing stainless steel, for instance, and similar materials which require much more complex machinery for even the simplest and most fundamental modification.

Those knowledgeable in the art will appreciate that the employment of syntactic foam material for deep submersible instrumentation package assemblies in accordance with the principles as taught by the present invention is such that the depth capability is only limited by the state of the art of the syntactic foam or comparable material. The present state of the art allows use of deep submersible instrumentation package assemblies fabricated in accordance with the concept of the present invention to depths of 20,000 feet. As syntactic foam materials are improved, the concept of the present invention may be readily extended to assemblies for use at greater depths.

Moreover, the teaching of the present invention is not limited to the specific configuration shown in the illustrated embodiments, but may include any combination of shapes, forms, and configurations as are necessary or desirable for particular applications. Also, in addition to the numerous combinations of forms suggested, the present invention may be embodied in a solid piece of syntactic foam material machined to provide an appropriate hollow interior and provided with a suitable cover.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings.

We claim:

1. A deep submersible instrument package assembly comprising:

a syntactic foam body member formed to receive an instrument;

at least one cover member formed of syntactic foam and configured to fit on said body member for enclosing said instrument therein;

means securing said cover member in pressure contact with said body member for sealing said enclosed instrument against outside deep submergence pressures;

said body and cover members being of selectively determined buoyant bulk relative to the weight of said assembly, including said enclosed instrument, for providing a desired predetermined degree of aggregate buoyancy in the medium where said assembly is to be submerged.

2. A deep submersible instrument package assembly as claimed in claim 1 wherein the selectively determined buoyant bulk of said body and cover members is predesigned for providing positive, negative, or neutral aggregate buoyancy as desired.

3. A deep submersible instrument package assembly as claimed in claim 1 wherein each said cover member is of substantially hemispherical form.

4. A deep submersible instrument package assembly as claimed in claim 3 wherein said body member is of substantially cylindrical form.

5. A deep submersible instrument package assembly as claimed in claim 3 wherein said body member is of substantially hemispherical form.

6. A deep submersible instrument package assembly as claimed in claim 1 wherein said means securing said cover member in pressure contact with said body member is adapted for removal of said cover member.

7. A deep submersible instrument package assembly as claimed in claim 6 and including aligned spaced apertures in said body member and said cover member for receiving said securing means, said apertures being positioned and configured to permit no entrapped voids thereupon upon receiving said securing means.

8. A deep submersible instrument package assembly as claimed in claim 7 wherein said body member and each

said cover member includes matching flanges for securing said members.

9. A deep submersible instrument package assembly as claimed in claim 8 wherein said body member is substantially cylindrical in form having flanges configured to fit flat cover members at each end thereof.

10. A deep submersible instrument package assembly as claimed in claim 1 and including a fitting sealed in one of said members for providing signal communication from the outside of said assembly to the instrument enclosed therein.

11. A method of fabricating a deep submergence instrumentation packaging assembly comprising the steps of:

shaping a block of syntactic foam material to approximated outside dimensions;

forming a cavity within said block for receiving an instrument;

securing cover means over said cavity in pressure contact with said block for sealing said instrument

against deep submergence environmental conditions;

determining the aggregate buoyancy of the entire assembly including the instrument enclosed therein; and

removing a sufficient amount of excess syntactic foam material from the outside of said block to provide the desired degree of positive, neutral, or negative buoyancy.

12. A method as claimed in claim 11 including the step of forming a cavity opening to only one end of the block of syntactic foam material.

13. A method as claimed in claim 11 including the

step of forming cover means by removing at least one end portion of said block before forming a cavity therein.

14. A method as claimed in claim 13 including the step of forming spaced holes in said block before removing an end portion to form a cover means whereby alignment of the holes in the cover means with those in the block is assured to receive securing means.

15. A method as claimed in claim 11 wherein the block of syntactic foam material is sawn to approximated outside dimensions.

16. A method as claimed in claim 15 wherein the block of syntactic foam material is sawn to approximated rectangular outside dimensions.

17. A method as claimed in claim 11 wherein excess syntactic foam material is removed from said block so as not to reduce its minimum wall thickness from its outside to the cavity within.

18. A method as claimed in claim 11 wherein excess syntactic foam material is removed from said block using a wood working tool.

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