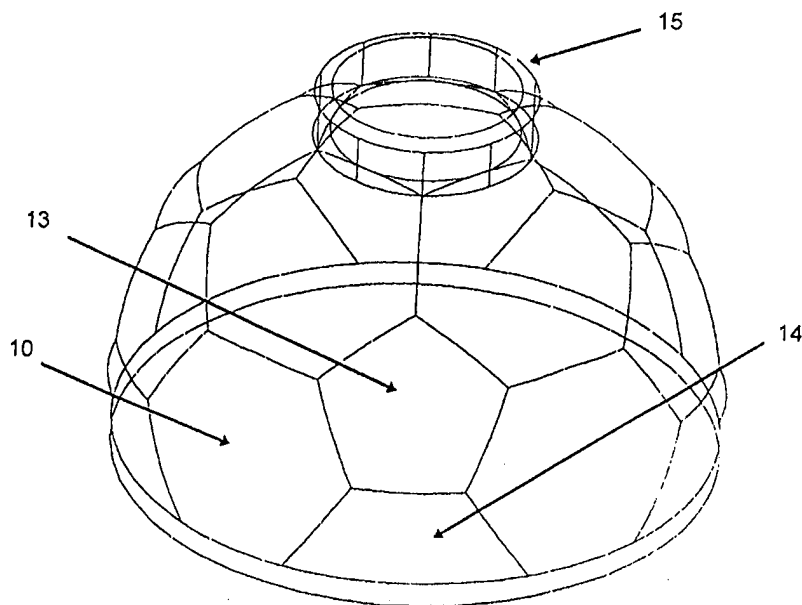




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<p>(21) International Application Number: PCT/GB98/00036 (22) International Filing Date: 15 January 1998 (15.01.98) (30) Priority Data: 9700716.5 15 January 1997 (15.01.97) GB (71)(72) Applicant and Inventor: AVIRAM, David, Paul [GB/GB]; 21 Rowlls Road, Kingston Upon Thames, Surrey KT1 3ET (GB).</p>	<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	

(54) Title: INTERLOCKABLE STRUCTURAL PANEL SETS



(57) Abstract

Structural panel sets (10, 13, 14) composed of light and demountable panels, that interlock along their periphery, thus forming a structural form that is weather sealed and thermally efficient. The panel sets, composed of at least two parts (1, 2), depend upon a flexible connecting strip (11) and a peripheral tongue and groove connection (3) method for rapid erection of structural forms. A system of clamping devices (6) allows rapid mounting and joining of neighbouring panel sets. One embodiment of such a system may be in the form of a composite demountable geodesic dome. The inherent structural and thermal efficiency of such a dome makes it particularly suitable for construction with interlockable composite panels. The dome may be suitable for a multitude of applications such as field hospital, extreme environment accommodation unit and as a storage unit for perishable goods.

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Interlockable structural panel sets

The invention relates to structural panel sets.

5 Structural panels are known and used in the construction of permanent or temporary buildings like walls, hangars, space structures, geodesic domes and stage sets. The structural integrity of this type of structural form is dependent upon bolted or pinned connections at the nodal positions of each panel.

10 US 4,309,852 describes a geodesic structural configuration where connection between neighbouring panels is dependent upon peripheral nodal connections. The method of connection employed has a low load transmission capacity and leaves a gap between adjacent panels, such that an additional external cover needs to be applied after the structure has been erected. The method of connection is
15 complex to manufacture and seal and is dependent upon alignment of all the individual connectors.

As a consequence of this design approach, a limitation is imposed upon the type, thickness, shape and minimum number of panels that may be used in the
20 construction of a dome.

It is an aim of the present invention to provide a structural unit which can be used for producing permanent or temporary structures of a type that is not made in a conventional manner and that will overcome the limitations mentioned above.

25 Accordingly, this invention provides for a set of interlockable structural panel sets that are characterized in that a panel set is made of at least two parts that facilitate clamping a means of connection between adjacent panel sets.

30

Several panel sets, according to the invention, may be joined to provide a structural form. Each panel set is comprised of at least two parts that facilitate the connection between neighbouring panel sets. The method of connection provides
5 for both transmission of loads as well as weather proofing. For connecting neighbouring panel sets, the panel sets are clamped upon the joining strip from either side, thus effecting the connection.

The connection means may be elastic. This has the advantage of allowing for
10 relative movement and damping effect between adjacent panel sets. Such movement may occur as a result of thermal and wind loading and especially under earthquake loads.

Preferably, the panels of each panel set have facing peripheral protrusions for
15 clamping the connection means. The connection means may preferably consist of an elastic H-section strip such that its flanges may be clamped within the panel's protrusions and the web of the strip providing the connecting medium between adjacent panel sets. The H-section strip may have cross section variations and may be reinforced internally for greater load bearing capacity. The use of an
20 elastic strip prolongs the life of the parts by eliminating surface erosion of the panel connecting parts.

In order to facilitate rapid assembly of the panel sets, the means of connection may be secured to at least one part of at least one edge of one panel. In one
25 preferred embodiment of an H-section strip, the strip may be secured to three successive edges of one part of the set so as to form a tongue and groove arrangement between neighbouring panel sets.

The preferred form of the panels is of triangular, rectangular, trapezoidal,
30 pentagonal or hexagonal shapes. The panels may be curved or flat and may consist of composite materials or any other suitable material of high strength to weight ratio. Composite construction has the advantage of providing high thermal resistance and thereby reducing the heat losses from a structure made with these panels.

In one preferred embodiment of the invention, a panel set consists of two parts, that are drawn together by clamping means allowing relative orthogonal positioning of the two parts of the panel set. Such clamping means may be achieved by clamping handles that draw together the parts, thereby effecting both
5 clamping and correct positioning of the parts of the panel set.

In the unclamped position the parts of the panel set may be maintained in the open position by means of an elastic separation device, such as a spring, for the purpose
10 of assisting the joining of panel sets.

The panel sets, according to the invention, may be advantageously used in the construction of a demountable geodesic dome. For this application the panel sets are made of at least one external and one internal part for clamping connection
15 means between adjacent panel sets.

One preferred form of the geodesic dome consists of 21 matching curved panel sets of hexagonal, pentagonal and semi hexagonal shape. Each panel set is made of external and internal parts.
20

The geodesic dome may be attached to the ground by means of a series of peripheral piles through the lower dome panel sets.

In one preferred embodiment of the geodesic dome application, the dome may be
25 used for storage of large agricultural machinery or for light aircraft hangarage and have an access door that does not cover more than half the surface area of the dome. For such application of a temporary structure, energy needs may be supplemented by means of an electric generator driven by a vertical wind turbine that is preferably installed at the apex of the dome. The location of the wind
30 turbine at the apex of the dome benefits from the low pressure and enhanced velocity of the wind by virtue of the curvature of the dome.

The panel sets, according to the invention, may also be advantageously used in the construction of a demountable floor. For this application the panel sets are made of at least one upper and one lower part for clamping connection means
5 between adjacent panel sets. Such a construction may be used in the erection of temporary floors for stage sets, various demountable or permanent structures.

Support for a floor made of panel sets, as described above, may be made by intermediately positioned legs.
10

A floor may also be attached to the lowest panels of a demountable geodesic dome as described above in order to provide a better structural and environmental form. The floor panels may interlock with the lowest dome panels in the same manner as the dome shell panels.
15

One embodiment of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Fig. 1 shows a cross section of two adjacent panel sets with means of connection;
20

Figs. 2A to 2D show different joining strip sections;

Fig. 3 shows a plan array of four panel sets;

25 Fig. 4 shows a perspective view of a demountable geodesic dome made of panel sets according to the invention;

Fig. 5 shows a cross sectional view of a demountable geodesic dome made of panel sets according to fig. 4.

Fig. 1 shows a cross sectional view of two adjacent panel sets. Each panel set consists of two parts 1 and 2. The two parts have facing peripheral protrusions 4. The two parts 1 and 2 of each panel set are drawn together by means of overcentre clamping handles 6. The clamping handles 6 pull studs 5 that are fixed to one part 1 of the panel set and pass through the matching part 2, such that the protrusions 4 at the periphery of each part 1 and 2, clamp the entrapped joining strip 11.

The joining strip 11 is made of an elastic material, such as neoprene rubber, of an H-section, consisting of flanges 3 connected by a web 7. At the clamped position the two internal surfaces 8 of each part, 1 and 2, are separated by virtue of the existence of the clamped H-section strip 11. This feature allows full load bearing capacity to be maintained along the entire length of each strip. Additionally, the elastic material will make a totally sealed connection, such that the structure may be hermetically sealed.

Imposed loading, such as wind, snow, thermal and earthquakes loadings will produce movement in the structure that will be absorbed through the elasticity of the joining strip 11. The elastic joining strip will also act as a damper under imposed dynamic loading such as wind and earthquake loads.

The joining strip 11 may have cross section variations, as shown in Figs. 2A – 2D. Fig. 2A shows a basic H-section with flanges 3 and web 7. Fig 2B shows an H-section with internal sloping flanges 3. This feature assists in drawing two neighbouring panel sets together. Fig. 2C has a central separating flange 9 along the middle of the web 7. This feature enhances the sealing of two neighbouring panel sets as well as prevent chafing of the opposite surfaces of the edges of the panel sets. Fig. 2D consists of two external sealing strips, with a separating middle part that increases the overall depth of the section. This feature improves the moment capacity of the section.

Fig. 3 shows a plan of an array of four panel sets 10 with the position of the joining strips 11. Each panel, under such configuration, has joining strips secured to the three uppermost edges of each panel set. The joining strips may be secured to both parts of each panel set at the uppermost edge, thereby effecting a tongue and groove connection at each panel set edge 12.

Fig. 4 shows a perspective view of a demountable geodesic dome made of panel sets according to the invention. A geodesic dome measuring six meters in diameter for primary use as an accomodation unit has polygonal panels that may contain windows and doors. The dome consists of an array of twenty-one sets of polygonal curved panel sets, including ten hexagonal panel sets 10, six pentagonal sets 13, and five semi-hexagonal sets 14. With increasing diameter, a greater number of panels will have to be used in order to maintain a minimum size and weight per panel that can be handled by a single person.

At the apex of the dome, a wind turbine 15 is positioned for the purpose of generating electrical power.

Fig. 5 shows a cross sectional view of a demountable geodesic dome made of panel sets according to fig. 4. The geodesic dome consists of shell panel sets 18 and floor panel sets 17 that are linked by edge panel sets 16. The method of connection of the panel sets is the same as described in fig. 1.

The edge panels are secured to the ground by means of a series of adjustable and demountable piles 19. The floor of the dome is supported by series of adjustable legs 20 at intermediate positions.

Claims

1. Interlockable structural panel sets (16, 17, 18) characterized in that a panel set is made of at least two parts (1, 2) for clamping connection means (11) between adjacent panel sets.
5
2. Interlockable structural panel sets according to claim 1 characterized in that the connection means (11) are elastic.
- 10 3. Interlockable structural panel set according to claim 1 or 2 characterized in that the parts of the panel set have facing peripheral protrusions (4).
4. Interlockable structural panel set according to claim 2 or 3 characterized in that the means of connection (11) consist of an elastic H-section joint with flanges (3) clamped within the panel protrusions (4).
15
5. Interlockable structural panel set according to claim 4 characterized in that the H-section joint (11) has internal reinforcement.
- 20 6. Interlockable structural panel set according to one of claims 1 to 5 characterized in that at least some of the means of connection (11) are secured to at least one edge of one part of at least one panel.
7. Interlockable structural panel set according to one of claims 1 to 6 characterized in that the parts of one panel set are drawn together by clamping means (5, 6) allowing relative orthogonal positioning of the parts (1, 2) of the panel sets.
25
8. Interlockable structural panel set according to one of claims 1 to 7 characterized in that the panels are of polygonal flat or curved shapes.
30

- 5 9. Demountable geodesic dome consisting of interlocking panel sets according to one of claims 1 to 8 characterized in that the panel sets are made of at least one external (1) and at least one internal (2) part for clamping connection means (11) between adjacent panel sets.
- 10 10. Demountable geodesic dome according to claim 9 characterized in that the lower dome panel sets (16) are attached to the ground, preferably by piles (19).
11. Demountable geodesic dome according to claims 9 or 10 characterised in that it is made of twenty-one matching panel sets, comprising of ten hexagonal (10), six pentagonal (13) and five half hexagonal (14) panel sets.
- 15 12. Demountable geodesic dome according to one of claims 9 to 11, characterized in that it has at least one access door that does not cover more than half of the surface area of the dome.
- 20 13. Demountable geodesic dome according to one of claims 9 to 12, characterized in that it is equipped with a vertical wind turbine (15) at the apex of the dome.
- 25 14. Demountable floor made of interlockable panel sets according to one of claims 1 to 8 characterized in that the panel sets are made of at least one upper (2) and at least one lower (1) part for clamping connection means (11) between adjacent panel sets.
- 30 15. Demountable floor according to claim 14 characterized in that at least some of the panel sets are supported by legs (20).
- 35 16. Demountable geodesic dome according to one of claims 9 to 13 characterized in that it has a demountable floor according to one of claims 14 or 15 and that at least some of the lowest dome panel sets interlock with the adjacent floor panels.

FIG. 1

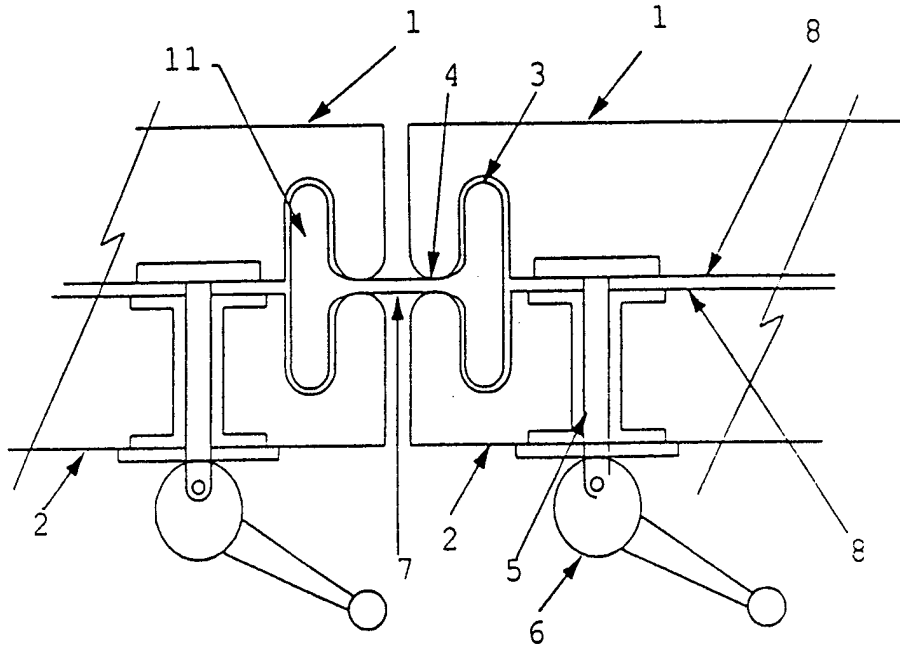


FIG. 2A

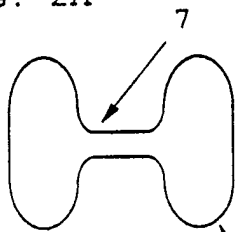


FIG. 2D

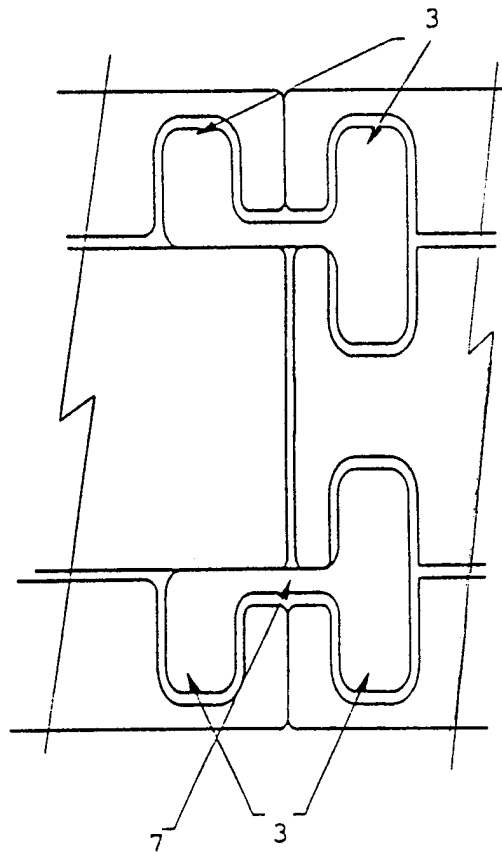


FIG. 2B

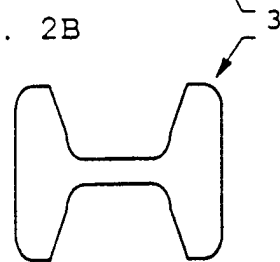


FIG. 2C

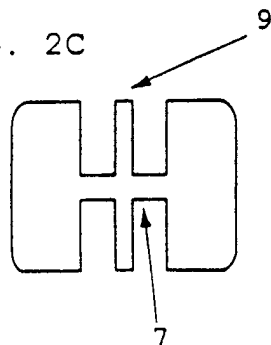


FIG. 3

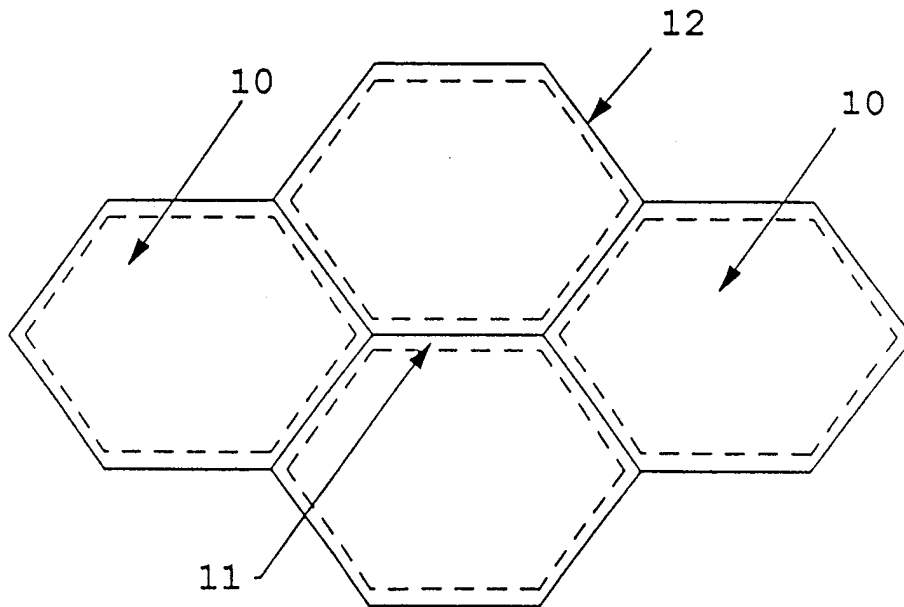


FIG. 4

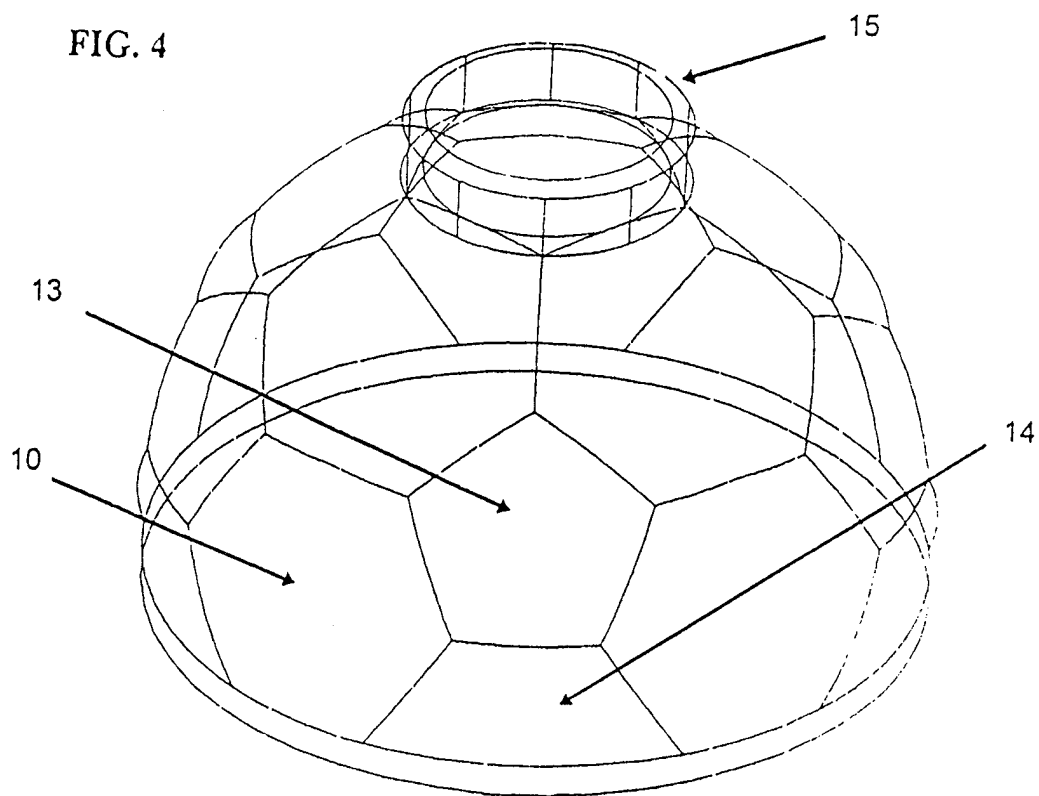
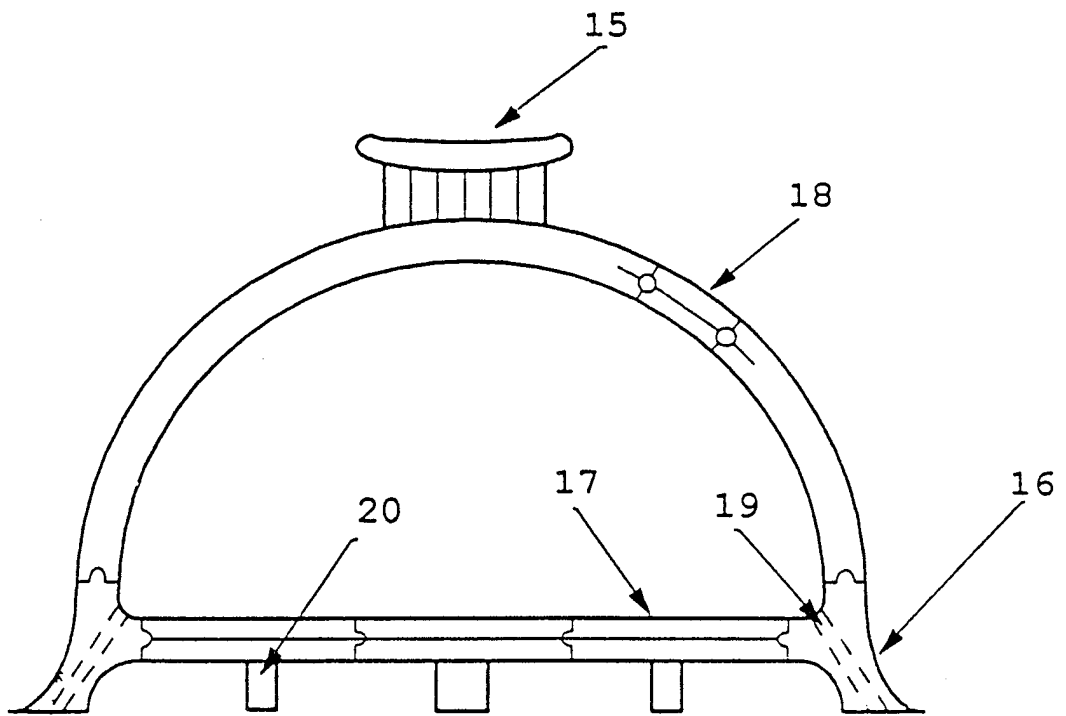


FIG. 5



INTERNATIONAL SEARCH REPORT

Internat' Application No PCT/GB 98/00036

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 E04B1/32 E04B1/343

According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)
 IPC 6 E04B

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Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 965 970 A (DANIELA NANIA) 30 October 1990 see column 3, line 36 - column 4, line 6; figures 1-3	1-10, 14-16
A	---	
A	US 4 640 061 A (RICHARD L. TRUMLEY) 3 February 1987 see column 6, line 62 - column 7, line 32; figures 1,2,9,10	1-6,8,13
A	---	
A	FR 2 662 456 A (TISSIER PIERRE) 29 November 1991 see claims 1-10; figures 1,4	1-3,7-9, 11,14-16
A	---	
A	WO 83 00892 A (BERGER, WILLIAM, R. ET AL.) 17 March 1983 see page 13, line 7 - page 14, line 4; figures 1-11	1,8-11

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 309 852 A (ROGER M. STOLPIN) 12 January 1982 cited in the application see abstract; figures 1,2,4 -----	1,2,8,9, 11

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4965970 A	30-10-90	CA 1320809 A	03-08-93
US 4640061 A	03-02-87	CA 1165086 A CA 1150029 A	10-04-84 19-07-83
FR 2662456 A	29-11-91	NONE	
WO 8300892 A	17-03-83	NONE	
US 4309852 A	12-01-82	US 4355781 A	26-10-82