Materials and Surrounding Structures for Implementation of "Medical" Modules In Extreme Situations

Lyudmila Aleksandrova

***Abstract:** The use of fruit warehouses (as a secondary use) for medical purposes in extreme situations requires appropriate solutions for protection of the structures from destructive external influence, e.g. concentrated hits by vehicles, sanitary carts and others. In this regard various solutions have been developed i.e. patented inventions for protection of the internal spaces in case of radiation, bacteriological contamination, military conflicts and others. Here are also explained the applications of stretched membranes as well as the use of tensegrity structures as a way of execution of protective screens for the chambers and volumes to be used under other harmful external conditions – acid rain, volcanic ash, formations of smog and others.*

***Keywords:** materials, surrounding structures, "medical" modules, extreme situations*

I. INTRODUCTION

The fencing structures of the "medical" modules, located in chambers as separate volumes / modules in extreme situations should be protected against: [1,2,3;] Falling objects resulting from secondary partial tremors caused by earthquakes; Mechanical damage of the surface layers of the panels and their connections; Hits by vehicles, including sanitary gurneys as they move from the pre-operative, Anesthesiology room to the operation room, etc.;- Impact noise penetration in key areas of the operation block - operation room, prep room (post-op), anesthesiology room, ER, etc. Moreover, the surrounding structures should protect the internal spaces of the chambers against penetration of radiation, i.e. "radon" gas emitted by the earth's crust during an earthquake and after it; against penetration of bacteria during bacteriological contamination of the area and other harmful effects.

In this regard Y. Aleksandrov writes that "the secondary use of refrigerators with positive temperatures for medical and other purposes in extreme situations is an opportunity to multiply the effect of the creation of appropriately protected artificial environment, especially when there is a hazard to health, e.g. a bacteriological contamination of the area as a result of industrial accidents or war. In these cases, air-tight connections between panels ensure the air tightness of the spaces."

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II. CHAMBER TYPES

2.1. Chambers of existing fruit warehouses with a supporting structure in the refrigerated space.

Under Chapter 3 "Types of planning schemes for planning the placement of operation rooms/areas in refrigerators"; part of the monograph "Exploitation of medical modules and sub-modules in extreme situations", 2016, depending on the size of the chambers of the existing fruit warehouses and cold stores in them can be paced one, two, three or four operation rooms, etc. From the standpoint of extreme situations, the most mobile, capable of relocating in different areas are the newly build movable chambers or volumes with dimensions corresponding to the dimensions of the operation rooms, e.g. 6 x 6 m.

2.1.1. Placing an operation room in a chamber (Tables 1, 2, 3). Analysis.

The chamber walls serve as walls for the operation room as well. Possible arrangement of the chambers:
- the freezer and operation room have common walls;
- the walls and the chamber and operation room are separated from each other by an installation space ;
- in some cases there are only one or only two common walls and the other two walls are separated from the walls of the chamber by an installation space.

Operation room (OR) with dimensions of 6 x 6 m and an area of 36 m^2, located in a chamber with dimensions of 6 x 6 m and an area of 36 m^2. The chamber walls are also walls of the operation room. (**Table 1.)**

Operation room with dimensions 6 x 6 m and an area of 36 m^2, located in a chamber with dimensions of 6 x 9 m and an area 54 m^2. The chamber walls are also walls of the operation room. (**Table 2.)**

Operation room measuring 6 x 6 meters and having an area of 36 m^2, located in chambers with dimensions 9 x 9 m and an area of 81 m^2. The walls of the chamber are separated from the walls of the installation space with a width of 1,50 m. (**Table 3.)**

2.2. Chambers of existing fruit warehouses and refrigerated warehouses with supporting structure outside the refrigerated space.

In Chapter 5 of the work of the author "Operation of medical modules and sub-modules in extreme situations" is shown the design of an operation rectangular block with three operation rooms and one longitudinal and one perpendicular serving corridors. (3.7.1 –

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Table 19.) The sample plan of the operation block with three operation rooms – two with general profile and one to conduct operations on the heart and vessels is shown in **Table 4. (Fig.1;)**

1.2.1. Analysis of the planning scheme according to Ukrainian standards.

Two operation rooms *1.2* and *1.5* with surgical profile have the dimensions of 6x6 m and the area of 36 m^2. *1.7* One operation room to conduct operations on the vessels and the heart with an area of 6 x 8 meters and an area of 48 m^2 include three operation rooms *1.7*, *1.2* and *1.5* with three separate rooms for anesthesia. There are also preparation rooms *2a* and *2b* for two medical workers. One of them serves operation room 1.7 to conduct operations on the heart and vessels and operation room with surgical profile *1.2*. The other serves the second operation room with surgical profile *1.5*. Three sterilization rooms are common to the three operation rooms *1.7*, *1.2* and *1.5*. One operation room to conduct operations on the heart and vessels has three entrances from the assembly for positioning apparatus for artificial circulation *10* and *1.7* to the operation room, anesthesia room *4* from to operation room *1.7* and the preparation room *2b* for medical staff to the operation room *1.7*. The mounting apparatus for positioning the artificial circulation *10* is connected to the washing apparatus for artificial circulation *10b*. Two operation rooms with surgical profile *1.2* and *1.5* have two entrances. One entrance is situated next to the preparation room *2a* and *2b* for medical personnel to operation rooms *1.5* and *1.2* and the other input is from anesthesia room *4* to operation room *2*. Patients must enter through the gateway *30*.

III. TYPES OF NEW TECHNICAL SOLUTIONS OF THE CHAMBERS OR VOLUMES FOR MEDICAL PURPOSES, INCLUDING THEIR WALLS.

3.1. BG 66192 (B1) — Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations. [4]

The invention will find application in the construction of temporary medical modules (operation theatres) in extreme situations with facilities for longer maintenance of constant temperatures in the hot water vessels, as well as for air heating due to the hothouse effect formed at the angular installation spaces. The water collectors (18) have collector coil (28) and are connected from below with a lower horizontal tube (29) and in its upper end to an upper horizontal tube (27), one of the ends of which is connected to a vertical tube with lower circulation pump (5). The latter is further connected to a lower horizontal accumulation tube (36), connected to accumulation coils (2), connected to an upper horizontal accumulation tube (37), connected to the upper circulation pump (1) and it, on its turn is connected to the other end of the lower tube (29). Coils (2) are fitted in first hot water vessels (4), the walls of which are resting to second vessels (3) for rain water and a blast fan (32) is fitted in the heat-insulation wall (11) to the first angular installation space (8) at a level over the suspended ceiling (38). On the same level but at the second angular installation space (12), in the other perpendicular heat insulation wall (11) an exhaust fan (33) is found, connected by means of a short duct (39) with the environment. **(Fig. 2)**

IV. PROTECTION OF ENCLOSING STRUCTURES WITH THE HELP OF ELASTIC COVERING

The walls of the operation rooms and the premises of the operation block, situated in newly built chambers should be protected against hits by sanitary carts, falling objects, etc. Therefore, these walls should be protected with the help of elastic materials, whereas Y. Aleksandrov reviews three of his technical solutions with inventive step, published on the resources of the International Patent Office “Espacenet”.

3.1. The first solution offers an elastic screen, situated in front of the wall panels with the help of elastic con-like elements; this elastic screen is hanged on plugs, inserted into cone-like openings, situated in the panel; T-shaped elemetns are connected with the plugs by threading; the hits on the screen are absorbed symmetrically by the sides of the panel. [Y. Aleksandrov. Patent BG 401 (Y1). Connection between panels. **[8]; (Fig. 3.)**

3.2. With an elastic sheet, stretched over elastic elements that make part of the elastic insulating and hung to elastic ends of the surface panel layers; the hits over the elastic sheet are absorbed by the console end of the semi-cylindrical element. [Y. Aleksandrov. Patent BG 62742 (B1). Wall panel. [9]; **(Fig. 4)**

3.3. With the help of the panel covering, made of hollow elements, where are situated strengthening bars made of a denser material or electric installation tubes, the hits are absorbed by this very covering and its strengthening bars. [Y. Aleksandrov. BG 63218 (B1). Multilayer panel with impact-protection and connection between panels. [10]; **(Fig. 5)**

V. CONSTRUCTION OF ENCLOSING STRUCTURES OF NEWLY BUILT CHAMBERS OR VOLUME ELEMENTS, WHICH ARE PARTIALLY TRANSPARENT AND THE CONNECTIONS BETWEEN THEM ARE GAS-IMPERMEABLE.

5.1. Patent for invention „Built-up refrigeration chamber“. BG63644 (B1). [11].

In the case of secondary use of fruit storehouses and refrigeration chambers for medical purposes in extreme situations, e.g. bacteriological contamination, it is required that the panel connections are gas-impermeable, whereas parts of their walls can be transparent. In connection to this, for instance, parts of the triangular panels, forming the ceiling are transparent, whereas the entrance doors of the chamber are situated in one or two of the chamber walls.

„The chamber is used in the construction of industrial refrigerators as well as in building of removable refrigeration tunnels. It achieves greater stability of the built-in volume. The four walls (1) of the chamber (2) are formed by beamed-walls (3) which have double T-section with trapeze-shaped belts.

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Panels (5), forming the ceiling and the floor of the chamber, have triangular shapes with chamfered peaks (6) and are fitted to each beamed-wall (3) by means of horizontal pivotal connections (4), fitted at the inner angle to the upper and to the lower trapeze-like belt of the beamed-walls (3) by their base or by a triangular panel (5), respectively. The triangular panels (5) are fixed to each other at their chamfered peaks (6) by a clamp (7) and on the fronts of the triangular panels (5) sealing strips (13) are fitted and the joints between the panels (5) at the floor and the ceiling are covered by gas-impermeable layer (8)." **(Fig. 6)**

VI. NEW TENDENCIES IN THE CONSTRUCTION OF CHAMBERS TO BE USED IN EXTREME SITUATIONS

The general model for innovative design, developed in the dissertation work of Y. Aleksandrov has been implemented by him in the creation of the new solutions with inventive step. **[4]**

6.1. Refrigeration chambers, intended for exploitation in extreme situations.

Here are reviewed small single-space chambers intended for use in positive temperatures ranging from 0^0 C to + 12^0 C, forming self-bearing construction elements.

6.1.1. Chambers made of vertical wall and horizontal stripe elements, combined with transparent two-plane and three-plane angular elements. (Fig. 7)

6.1.2. 5.1.2. Chambers of vertical wall and horizontal ceiling stripe elements, combined with three-plane angular and two-plane angular elements, whereas the joints are transparent. (Fig. 8)

6.2. Permanent two-space chambers for use in positive temperatures ranging from 00 to + 120C, made of elements, which are hung to the carrying construction, situated inside the chamber as well as outside the chamber. New solutions.

5.2.1. Chambers made of **dense** vertical wall stripe elements and **dense** horizontal ceiling stripe elements, combined with transparent three-plane angular and transparent two-plane vertical and horizontal angular elements as well as with outside T-shaped three-plane angular and transparent outside T-shaped two-plane angular elements. **(Fig. 9)**

Types of combinations with the transparent elements:- Only the three-plan angular elements; - Only the upper horizontal two-plane angular elements; -Only the vertical two-plane angular elements; - Only the lower horizontal two-plane angular elements] Or- Only the outside T-shaped three-plane angular elements; - Only the outside upper T-shaped two-plane angular elements; - Only the outside vertical T-shaped two-plane angular elements. In all cases the transparent elements are not covered with an outside protective screen.

VII. NEW APPROACHES TOWARDS THE REQUIREMENTS TO THE BUILDINGS, CONSTRUCTIONS AND THEIR DETAILS TO BE USED IN EXTREME SITUATIONS. APPLICATION OF TENSEGRITY-STRUCTURES WITH STRETCHED MEMBRANES USED FOR COVERING CHAMBERS AND VOLUMES, INTENDED FOR EXPLOITATION IN EXTREME SITUATIONS.

7.1. Definition of the difference between chambers and volumes.

The considerable difference between chambers and volumes consists in the fact that the enclosing structure of the chambers is protected by protective screens. These protective screens reflect solar radiation, while protecting the walls and the roof from over-heating. This allows for the insulation of their wall panels to be thinner, which leads to an economy in material. In practice, the carrying construction, while situated outside the chamber space, allows the protective screens to be hung. In the case when the carrying construction is situated inside the refrigeration space, these protective screens should be carried by their own carrying construction.

7.2. Tensegrity-structures with stretched membranes. (Fig. 10,11,12); [14, 15, 16;]

In case of extreme situations, the protective screens can have the form of membranes, carried by tensegrity-structures. The advantages of this solution are as follows:

- The chambers intended for use in positive temperatures, which have three-plane or two-plane transparent angular elements, can be covered by partially transparent membranes, which let pass the solar radiation inside the chamber space, while the dense parts of the membrane have a reflective function;
- Thus, the membranes allow the area of the transparent chamber surface to be regulated according to the geographic latitude, allowing for a temperature range from + 2^0 - $+8^0$ (fruit storehouses) to + 22^0 - $+24^0$ C (operation rooms), whereas the so-called **"regulated hothouse effect"** is used. [Y. Aleksandrov];
- On the membranes can be placed photo-voltaic elements that will produce which will serve as a source of artificial light in the operation rooms and operation blocks.

A protective membrane is stretched over a tensegrity-structure, whereas the chambers and volumes are "inserted" beneath. **(Fig. 10)**

The space under the stretched membrane is suitable for chambers and volumes to be situated beneath. **(Fig. 11)**

The spaces of unfinished multi-story constructions can be easily adapted to house the chambers and volumes to be used in extreme situations. **(Fig. 12)**

VIII. CONCLUSIONS

1. For medical use in extreme situations, most suitable are the single-space chambers and volumes as well as the two-space chambers and volumes, which allow maximal mobility and optimal geographic coverage.

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2. The gas-impermeable chambers intended for use in positive temperatures are suitable to be used in areas with bacteriological contamination occurring after industrial averages or military conflicts; they can also be used in case of increased radiation levels.
3. It is important that all newly built volumes are gas-impermeable. In this way, the exploitation options are considerably increased and their premises can be used not only for operation rooms but also as ER, preparation rooms, etc. thus covering the entire range of needs of the operation block.
4. Most suitable are the chambers and volumes intended for use in positive temperatures and allowing natural light to penetrate inside.
5. Electricity required to power the sources of artificial light inside the chambers and volumes can be generated by photo-voltaic elements, placed on the roof and hot water can be provided by solar water collectors, whereas water needs can be covered by rainwater, collected in special tanks or water provided by dwells or drills.
6. New construction elements, namely dense elements with elastic covering, transparent elements with three-plane, two-plane and T-shaped structure, as well as gas-impermeable materials for gas-impermeable panel connections should be manufactured.
7. The membranes, stretched over tensegrity- structures allow the chambers and volumes to be integrated in contemporary design solutions, simultaneously meeting the functional requirements for suitability for use for medical purposes in extreme situations.

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PATENTS OF THE AUTHOR

6. Aleksandrova Liudmila Patent BG66192 (B1). Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations. Classification: international: F24J2/42; cooperative: Y02E10/40. Espacenet.

OTHER PATENTS MENTIONED IN THE PAPER

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8. Aleksandrov Yanko BG 62742 (B1). Wall panel. Classification: E04C2/26; (IPC1-7): E04C2/26. Espacenet.
9. Aleksandrov Yanko BG 63218 (B1). Multilayer panel with impact-protection and connection between panels. Classification: international: E04B1/94; E04B1/98; E04C2/26; (IPC1-7): E04B1/98; E04C2/26. Espacenet.
10. Aleksandrov Yanko BG 63644 (B1). Built-up refrigeration chamber. Classification: E04B1/343; E04B1/74; E04H5/10. Espacenet.

PATENT APPLICATIONS

12. Aleksandrov Yanko BG 111651 (A). Moveable cold storage chamber for positive temperature. Classification: international; E04H5/12; Espacenet.
13. Aleksandrov Yanko BG 111658 (A). System for solar heating of cooling chamber with positive temperatures. Classification: international : E04B2/00 ; E04C1/00; Espacenet.

OTHERS

14. (www.pleatfarm.com)
15. (www.saziran.com)
16. (www.thorntontomasetti.com)

Associate Professor Lyudmila Aleksandrova is the author and co-author of more than 30 patents for inventions, whereas a significant part of them solve problems in the sphere of the energy efficiency of buildings, e.g. active-energy walls, energy-accumulating panel connections, systems for solar heating of buildings, sectional modules with autonomous energy supply for use in extreme situations, i.e. natural disasters, etc.
Associate Professor Lyudmila Aleksandrova in co-authorship is winner of the “Genius Grand Prix” and a Gold medal from the International Invention Fair in Budapest. Her papers have roused high interest at numerous international conferences on architecture and sustainable development, e.g. in Tokyo, Seoul, Hong Kong, Kuala Lumpur, Cape Town, Florence, etc.
She has been guest lecturer at the Faculty of Architecture of the Institute for Building
Management in Belgrade, Serbia as well as “Erasmus” lecturer at the Riga Building College, Latvia in 2012, 2013, 2014 and 2015.
The author teaches the course “Innovative design of buildings, constructions and details” at the Faculty of Architecture of the Civil Engineering Higher School “Liuben Karavelov” in Sofia, Bulgaria.
Associate Professor Lyudmila Aleksandrova together with her team has been finalist of several international Superskyscrapers competitions, e.g. Hong Kong – 2013, Singapore – 2014, London – 2014, “Elevator annual design competition” – 2014, TORONTO VELODROME – 2015; STEEL CITY - CONTAINER SKYSCRAPERS - MUMBAI, 2015; www.superskyscrapers.com, etc.

Table 1.

6m Operation area 6 x 6 = 36 m² 6m	Symmetrical arrangement of the operation space of the chamber. The axes of the walls of the chamber and operation area are the same. Therefore, the effective area will be less than 36 m^2. Coordination dimensions of 6 x 6 m changes to 6,30 x 6,30 m. This will compensate for areas of wall thicknesses, 10 cm and width of the protective reinforced concrete board - 2 x 10 = 20 cm. The door of the chamber, leading to the transport corridor is the door of the operation room. In the transverse walls of the chambers are provided sealed doors for the operation block.
Hallway 4,5-6m	

Table 2.

6m Operation area 6 x 6 = 36 m² 9m 6m	Symmetrical arrangement of the operation space of the chamber. The axes of the walls of the chamber and the operation coincide with two transverse walls and the outer wall of the chamber. Fourth wall between the operation and the wall of the transport corridor is designed area of 18 m^2, which is part of the area of the surgery ward. Coordination OR dimensions of 6 x 6 m change of 6,30 x 6,30 m. This will compensate for areas of the thickness of the walls, 10 cm and width of the protective reinforced concrete board - 2 x 10 = 20 cm. In the transverse walls of the chambers are provided sealed doors for the operation block.
18m² Area	
Hallway 4,5-6m	

Table 3.

1,5m 9m 1,5 m 6m OR 6 x 6 = 36 m² 1,5m 1,5m	Symmetrical or island-like situation of the operation space of the chamber. The axes of the walls of the chamber and the walls of the OR do not match, as well as the longitudinal and the transverse sides. Between the walls of the operation chamber is shaped a bypass sanitary installation corridor with axial width of 1,5 m. The thickness of the walls of the chamber and the operation room will reduce the distance by 20 cm and it will be 1,30 m. In the hallway but outside the walls of the operation room are placed the installations. In the transverse walls of the chambers are placed the sealed doors of the operation block.
Hallway 4,5-6m	

Table4.

Operation block with three operation rooms: two with a general surgical profile and one to conduct coronary operations. Optional angular corridor.

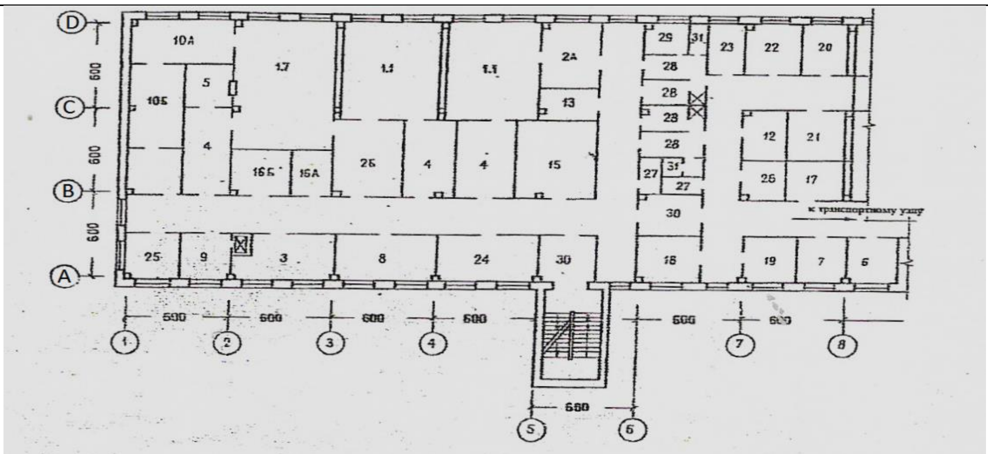

Fig.1. Standards of Ukraine. Sample planning. Operation block of three operation rooms with dimensions of 18 x 42 m.

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Sizes and areas of the operation block.	*m*	m^2
● Minimum sizes and focal areas under the scheme.	18 x 42	756
● Appropriate sizes of existing refrigeration chambers bearing structure outside the refrigerated space.		

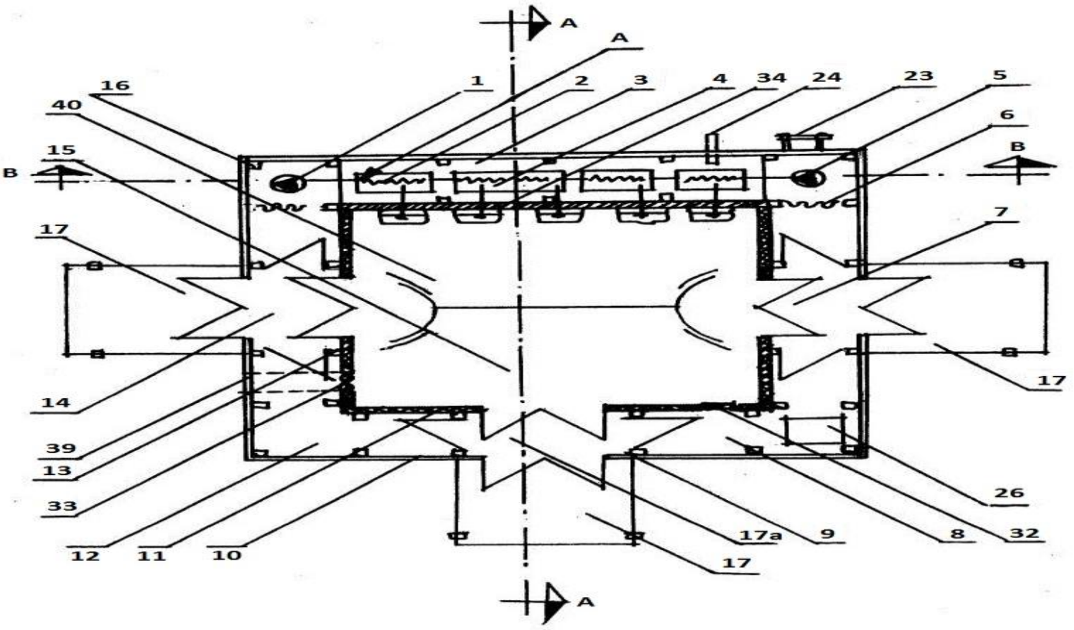

Fig. 2. Plan. Patent BG66192 (B1) – Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations. [4]

A- tube system; (1) - upper circulation pump; (2) - accumulation coils; (3) - second vessels; (4) - first hot water vessels; (5) - lower circulation pump; 6 - thermo-insulating curtain; 7 - second exit to the emergency room; (8) - first angular installation space; 9 - columns; 10 - transparent wall; (11) - heat-insulation wall; (11) - other perpendicular heat insulation wall; (12) - second angular installation space; 13 – other columns; 14 - entrance; 15 - operation room; 16 - bearing angular columns; 17 - loading platform; 17a - exit to the hospital; (18) - water collectors; 19 - other photo-voltaic elements; 20 - inclined plate; 21 - second floor; 22 - ballast bed; 23 - outside stairs; 24 - overflow drain; 25 - photo-voltaic elements; 26 - electricity accumulator; (27) - upper horizontal tube; (28) - collector coil; (29) - lower horizontal tube; (29) - lower tube; 30 - horizontal roof plate; 31 - shelter; (32) - blast fan; (33) - exhaust fan; 34 - energy-radiating wall; (36) - lower horizontal accumulation tube; (37) - upper horizontal accumulation tube; (38) - suspended ceiling; (39) - short duct; 40 - premises for the preparation room and the narcosis room.

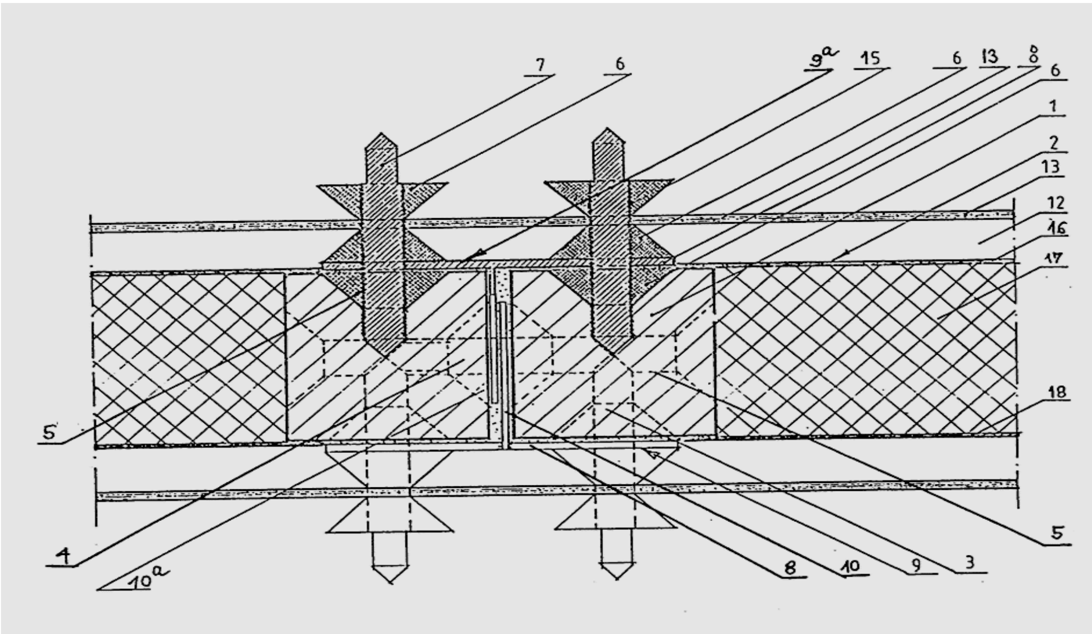

Fig. 3. Patent BG 401 (Y1). Connection between panels. [8]

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1 - sides; 2 - two panels; 3 - inlet; 4 - stud; 4&7 - connection threaded components; 5 - threaded holes; 6 - conical elastic parts; 7 - external studs; 8 - horizontally positioned part; 8 - horizontally fitted parts; 9&9a - two T-shaped profiles; 10&10a - two slanted arms; 11- gasket; 12- space; 13 - screen; 14 - electrical installations;15 - thread; 16 - surface layer of the panel; 17- heat insulation;18 - second surface layer of the panel.

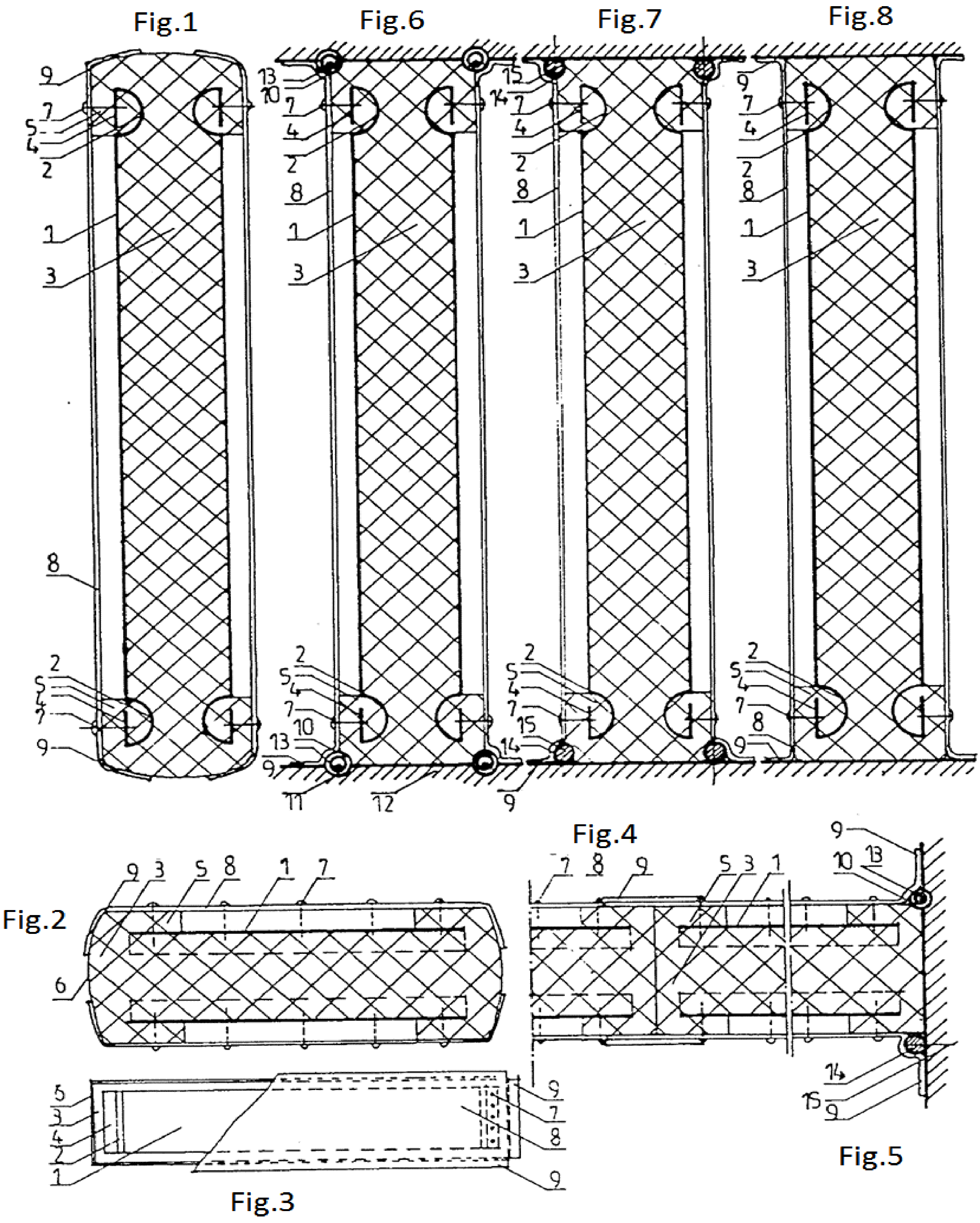

Fig. 4. Patent BG 62742 (B1). Wall panel. (Fig. 1- 8 from the patent); [9]

Fig.1 – longitudinal section through the panel, Fig.2 – transverse section through the panel, Fig.3 – view of the panel from its shorter side, Fig. 4 – panel connection, Fig.5 – connection between wall and panel, Fig.6 – connection among panel, floor and ceiling in a variant with elastic tube, Fig. 7 – connection among panel, floor and ceiling in a variant with elastic rope, Fig.8 – connection among panel, floor and ceiling in a variant with stretching.

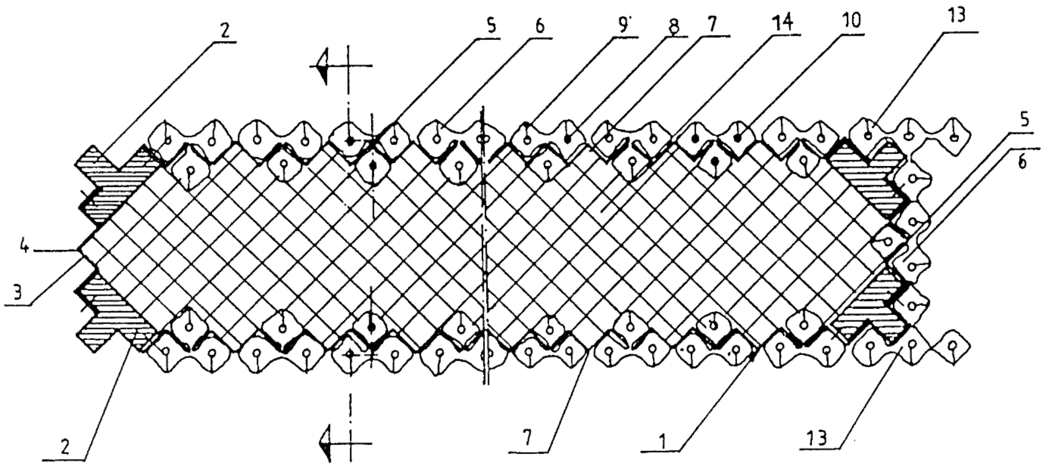

Fig. 5. BG 63218 (B1). Multilayer panel with impact-protection and connection between panels. [10]

1- panel; 2- four heat insulation inserts (2); 3- middle parts (3); 4- front zig-zagging sheets (4); 5- alternating rectangular holes (5); 6- star-like three-part elements (6); 7- zigzagging sheets (7); 8- central longitudinal hole (8); 9- longitudinal slot (9); 10- reinforcing rod (10); 11- single-part elastic element (11); 12- U-shaped three-part elastic element (12); 13- four-part elastic elements (13); 14- heat insulation (14).

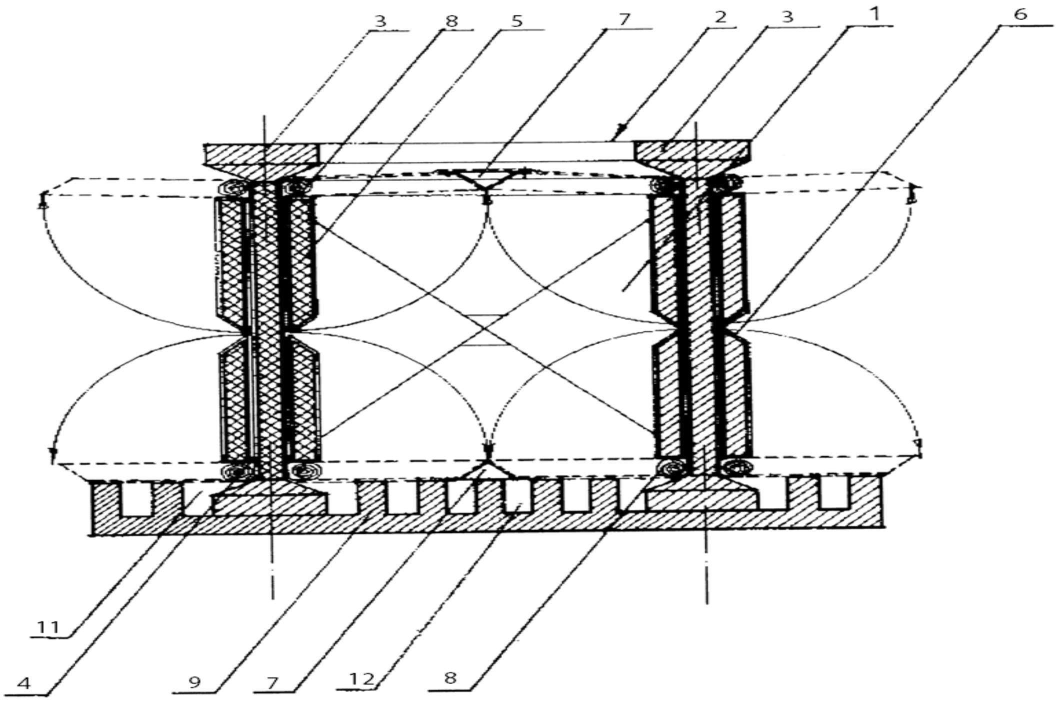

Fig. 6. Section. Patent for invention „Built-up refrigeration chamber". BG 63644 (B1). [11].

(1) four walls; (2) chamber; (3) beamed-walls; (4) horizontal pivotal connections; (5) triangular panels; (6) chamfered peaks; (7) clamp; (8) gas impermeable layer; (11) channel for foundation of the beamed walls; (12) channel.

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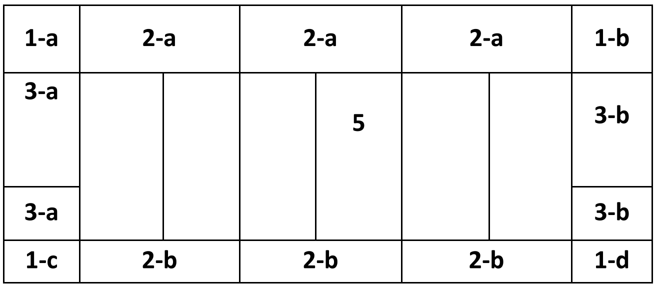

Fig. 7. Situation scheme of the construction elements of the enclosing construction in the case of single-space refrigeration chambers. All vertical wall stripe elements 5 are **dense elements**. **[12, 13]**

Transparent elements: 1-a – left upper angular three-plane element; 1-b – right upper angular three-plane element; 1-c – left lower angular three-plane element; 1-d – right lower angular three-plane element; 2-a – upper angular two-plane element; 2-b – lower angular two-plane element; 3-a – left vertical angular two-plane element; 3-b – right vertical angular two-plane element.

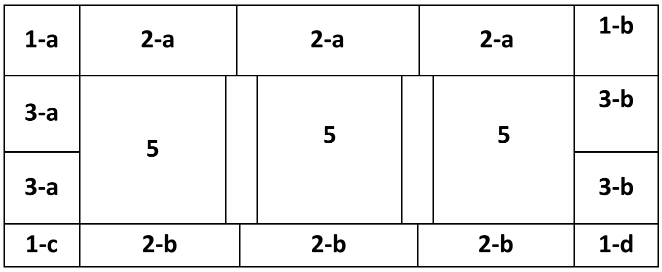

Fig. 8. Situation scheme of the construction elements of the enclosing construction in the case of single-space refrigeration chambers. Here the joints between the vertical stripe elements are transparent, covered of transparent insulating. The carrying construction of the elements is situated in the refrigeration space. **[12, 13]**

Dense elements: 1-a – left upper angular three-plane element; 1-b – right upper angular three-plane element; 1-c – left lower angular three-plane element; 1-d – right lower angular three-plane element; 2-a – upper angular two-plane element; 2-b – lower angular two-plane element; 3-a – left vertical angular two-plane element; 3-b – right vertical angular two-plane element; 5 – vertical wall stripe element.

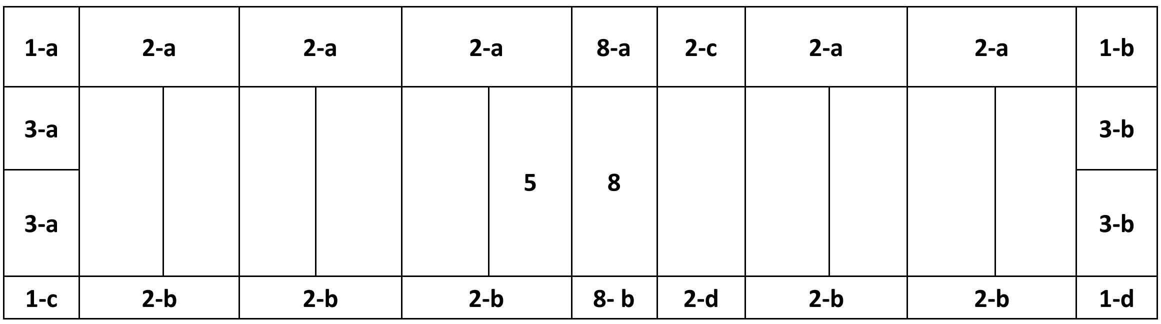

Fig. 9. Situation scheme of the construction elements of the enclosing construction of the outside wall of a two-space refrigeration chamber. Dense are only the vertical wall stripe elements 5. All other elements are transparent. The carrying construction of the elements is situated inside the refrigeration space. [12, 13;]

Transparent elements: 1-a – left upper angular three-plane element; 1-b – right upper angular three-plane element; 1-c – left lower angular three-plane element; 1-d – right lower angular three-plane element; 2-a – upper angular two-plane element; 2-b – lower angular two-plane element; 3-a – left vertical angular two-plane element; 3-b – right vertical angular two-plane element; 8 – outside T-shaped three-plane angular elements; 8-a – upper T-shaped three-plane angular elements; 8-b – lower T-shaped three-plane angular elements.

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Fig. 10. A vaulted tensegrity-structure. (www.pleatfarm.com); (14)

Fig. 11. Cutty sark pavilion by Bakoko. (www.pleatfarm.com); (14) Fig. 12. Shell and membrane system folded structures and tensegrity structure.(www.saziran.com); (15)

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Fig.13. Detail for stabilization of two perpendicular ropes. (www.thorntontomasetti.com); (16)

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