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NEW SOLUTION – REFRIGERATORS FOR FRUITS AND VEGETABLES THAT USE SOLAR ENERGY TO ACHIEVE POSITIVE TEMPERATURES

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Abstract

Aleksandrov, Y., 2017. New solution – refrigerators for fruits and vegetables that use solar energy to achieve positive temperatures. *Bulg. J. Agric. Sci.*, 23 (3): 498–504

Here are reviewed new solutions for fruits and vegetables that use solar energy in order to achieve positive temperatures. Furthermore, the main aspects of the basic requirements for their implementation are taken into consideration. Three typical solutions with inventive step of the author are reviewed. These are:

- BG63644 (B1). Built-up refrigeration chamber (Aleksandrov, 2002). The triangular panels 5, situated on the walls and the roof of the refrigerator chamber can be also made of transparent structures, whereas the chamber is directly situated on the respective terrain over a ribbed plate; the ribs form ventilation channels.
- BG № 111651/09.12.2013 г. Moveable cold storage chamber for positive temperature. BG111651 (A) (Aleksandrov, 2013a.) Transparent angular two-plane elements are used for the direct lighting of the floor and the ceiling of the refrigeration chamber, the penetration of solar beams is directed by sunblinds, which are controlled by sensors.
- BG № 111658/17.12.2013. System for solar heating of cooling chamber with positive temperatures. BG111658 (A). (Aleksandrov, 2013b) Solar water collectors are used for heating and hot water supply to meet various demands, e.g. to cover the technical needs (e.g. washing of root fruit and vegetables, etc.)

In extreme situations, the refrigerators for fruits and vegetables which operated under positive temperatures can be used for various other purposes, e.g. medical purposes – as premises for the situation of operating rooms. The transparent elements will allow the penetration of natural light, whereas water collectors will provide hot water for medical purposes. The application of tension membranes and tensegrity structures as a way of executing protective screens on refrigerators for fruits and vegetables under other harmful external conditions – acid rain, falling volcanic ash, formations of smog and others is also described.

Key words: refrigerators; fruits; vegetables; solar energy; patents

Introduction

In extreme situations, caused by natural disasters, e.g. earthquakes, floodings or big industrial averages (Chernobyl), as well as in case of military conflicts buildings and infrastructure are destroyed. Therefore, the construction or adaptation of large premises to be used for various purposes is required. Here, refrigerators for fruits and vegetables can be of great help, covering numerous different needs of the population. In connection to this, the faultless exploitation of these refrigerators should be ensured, especially with the help of renewable sources as energy, i.e. solar energy. The use of solar energy to supply refrigerators with positive temperatures, such as the refrigerators for fruits and vegetables in an inert gas environment (nitrogen) is highly suitable. The spaces of all these refrigerators can also be successfully adapted for use for various other purposes, e.g. medical purposes – operating rooms, ER, hospitals, etc. (Aleksandrova, 2016).

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Materials and Methods

In order to answer the requirements, various combinations of dense and transparent materials are suggested. The areas of the transparent materials can be regulated by sunblinds according to the requirements of the technological regime of the refrigerators for fruits and vegetables. The building methods allow the fast transportation and construction of these refrigerators by using built-up elements, described precisely in three patented solutions of the author (Aleksandrov, 2002; Aleksandrov, 2013a, b)

Requirements for the refrigerators for fruits and vegetables

The following requirements are essential in the design of the refrigerators:

a. They should allow their structures to be assembled/ disassembled;

b. To be constructed of lightweight materials that provide structure solidity and heat, steam and gas insulation;

c. The structures have to be air-tight (gas-tight), since this type of structures are particularly suitable for use in case of bacteriological contamination of the environmentt, e.g. in case of leakage of ”radon”; for the storage of fruits and vegetables intended for consumption in winter and spring; for medical purposes and others.

d. The construction technology should allow their easy and fast disassembling and relocating.

e. Their construction should allow the solar energy to be used in order to achieve positive temperatures therein as well as to obtain hot water for technological and similar purposes.

Discussion and analysis on the requirements

From the analysis of these requirements it can be deducted that the volumes for operation in extreme situations, should be made of prefabricated walls, floors and ceilings such as whole panels, striped vertical panels, horizontal strip panels and others.

Ensuring air-tight links between the prefabricated elements will broaden the spectrum of use of the volumes in other cases: operating rooms and operating blocks

An appropriate supporting structure will allow overcoming the support distances and will allow classified mixed functions, for example – pressurized volume space with an area of 36-40 m^2 can be used as an operating room, a temperature-controlled warehouse for storing blood products, medicines, food and others (Aleksandrova, 2016).

Typical author (copyright) solutions. Characteristic solutions of the author

The hothouse effect is of particular importance in the construction of built-up exploitation volumes in extreme situations.

The invention of Aleksandrova L. “Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations” – BG66192 (B1); (Aleksandrova, 2011) reveals that.

„The invention shall 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“ (Aleksandrova, 2011). Thus, hothouse effect could be created in the aerial space, situated between transparent external walls and dense internal walls of an operating room. (Figure 1) (Aleksandrova, 2016).

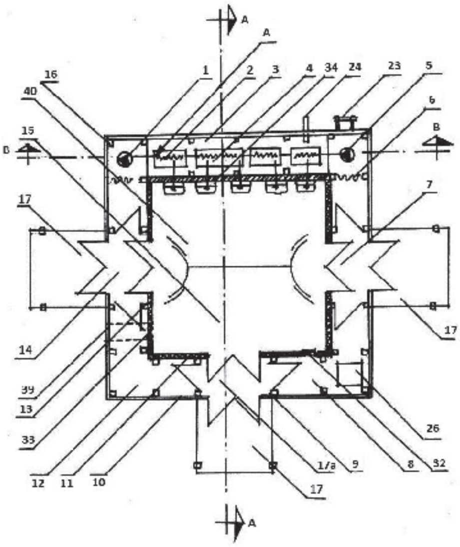

Fig. 1. Plan. Patent BG66192 (B1) – Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations

(Aleksandrova, 2011)

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 (11); (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

Innovative solutions with inventive step to be used in the production of refrigerators for fruits and vegetables with transparent elements

The triangular panels 5 situated on the walls and the ceiling are transparent; the connections are gas-impermeable. Built-up refrigeration chamber. BG63644 (B1). (Aleksandrov, 2002) (Figure 2, 3).

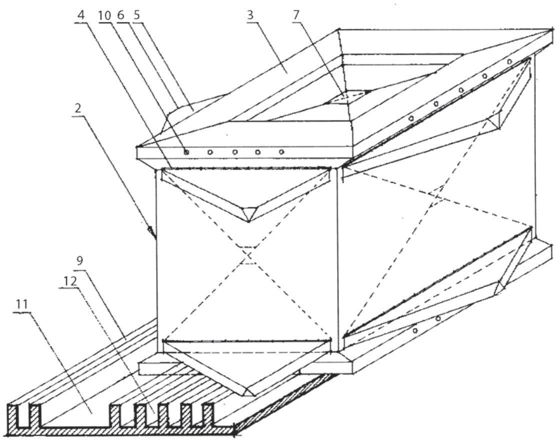

Fig. 2. Refrigerator for fruits and vegetables. General view. Patent for invention „Built-up refrigeration chamber". BG63644 (B1)
(Aleksandrov, 2002)
(1) four walls; (2) chamber; (3) beamed walls; (4) horizontal pivotal connections; (5) triangular panels; (6) chamfered peaks; (7) clamp; (8) gas impermeable layer; (9) rib; (10) cylindrical channels; (11) channel for foundation of the beamed walls; (12) channel

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. 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). 1 claim, 4 figures (Figure 2, 3).

The angular two-plane elements used in the floor and the ceiling are transparent – № 111651 / 09.12.2013 г.

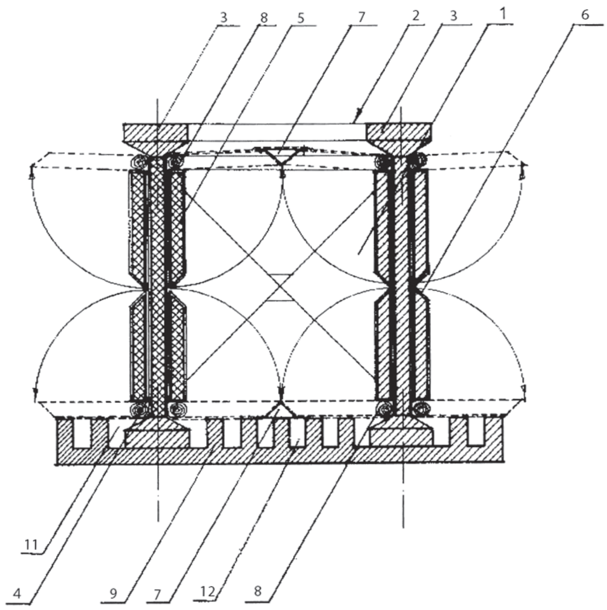

Fig. 3. Refrigerator for fruits and vegetables. Section. Patent for invention „Built-up refrigeration chamber" BG63644 (B1)
(Aleksandrov, 2002)
(1) four walls; (2) chamber; (3) beamed-walls; (4) horizontal pivotal connections; (5) triangular panels; (6) chamfered peaks; (7) clamp; (8) gas impermeable layer; (11) channel for foundation of the beamed walls; (12) channel

Moveable cold storage chamber for positive temperature BG111651 (A) (Aleksandrov, 2013a) (Figure 4, 5)

The invention relates to a Cold storage chamber having a natural lighting along the edges of the chamber to create a greenhouse effect. There is a possibility for artificial lighting and heating of the storage by converting solar energy into electricity through photovoltaic coatings. The cold storage chamber has a supporting structure of longitudinal transparent frames (12) and transverse transparent frames (12-a), as to the columns of the frames are installed inside transparent guides (11, 13) for securing the walls of the chamber. Along the edges of the chamber are situated transparent elements – three angular planar elements (1, 8) horizontal angular of two planar elements (2, 7), a T-shaped angular member (3, 6) and the vertical angular of two planar elements (4). The walls are covered by not transparent wall panels (10) secured to the inner side of the guides (11, 13) and the ceiling is made of not transparent ceiling panels (9) secured to the inner side of the transverse frames (12a). On the wall panels (10) and the ceiling panel (9) is arranged a photovoltaic coating. (Figure 4, 5)

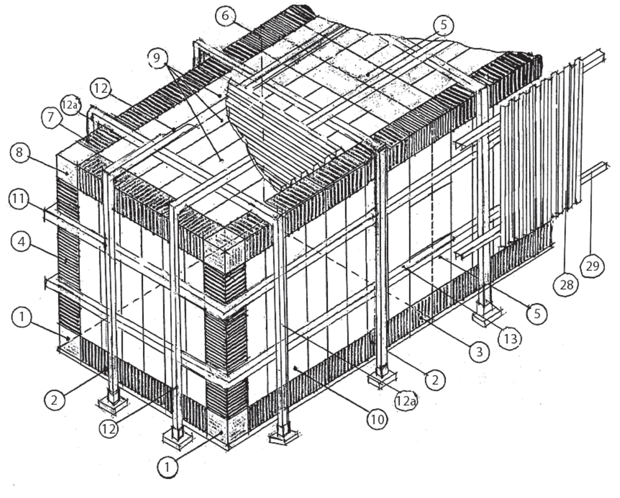

Fig. 4. Refrigerator for fruits and vegetables. General view. „Moveable cold storage chamber for positive temperatures". BG111651(A)

(Aleksandrov, 2013a)

(1,8) three angular planar elements; (2,7) two planar elements; (3,6) „T"-shaped angular member; (4) the vertical angular of two planar elements; (9) not transparent ceiling panels; (10) not transparent wall panels; (11,13) the inner side of the guides; (12a) the inner side of the transverse frames; (12-a) transverse transparent frames; (11,13) inside transparent guides

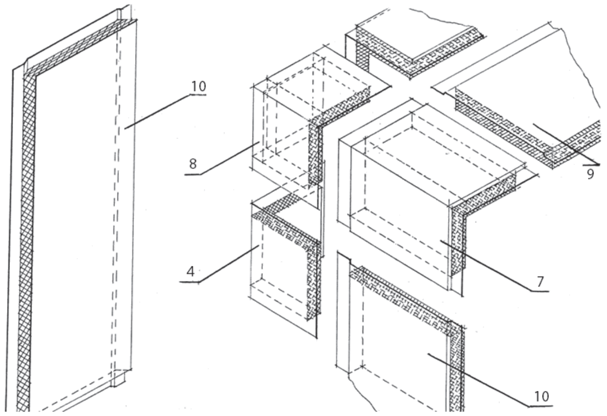

Fig. 5. Refrigerator for fruits and vegetables. The basic elements. „Moveable cold storage chamber for positive temperature". BG111651 (A)

(Aleksandrov, 2013a)

(4) vertical angular of two planar elements; (7) two planar elements; (8) three angular planar elements; (9) not transparent ceiling panels; (10) not transparent wall panels

The transparent angular elements are combined with solar water collectors situated on the roof of the refrigerator

System for solar heating of cooling chamber with positive temperatures. *№ 111658/17.12.2013* BG bg 111658 (A) (Aleksandrov 2013b) (Figure 6, 7)

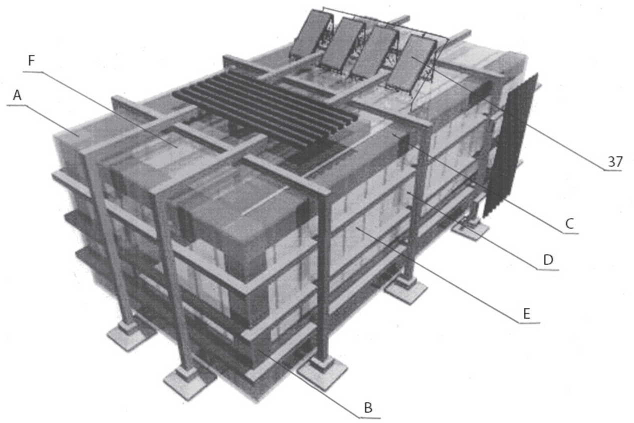

Fig. 6. Refrigerator for fruits and vegetables. Elevation. „System for solar heating of cooling chamber with positive temperatures." BG111658 (A)

(Aleksandrov, 2013b)

A – three flat corners; B – two flat corners; C – „T"-shaped three flat elements; D – „T"-shaped two flat elements; E – flat vertical elements; F – flat horizontal elements; 37 – collectors

The invention finds application in extreme situations and features with solar heating to achieve the positive temperature, with naturally absentmindedly solar lighting in the area of vertical joints between the panels, as well as with combined thermal insulation of walls and the roof of transparent thermal insulation, at least half-filled with energy accumulation composition. Three flat corner is filled with the external transparent layer (1-a), an inner dense layer (7), as in layers (7) shaped the first vertical zigzag channel (7-a) and the second horizontal zigzag channel (7-b), as in the channel (7-a) is a heirloom layer (6), and the zigzag shaped element (6) is fixed to the thick layer (7) with the connector (4), (7) and behind this layer (6) are located in the thin heating coils (3-b)and between the outer transparent layer (1-a) and the inner dense layer (7) is a transparent thermal insulation (2), with its transparent walls (2) are shaped confined spaces, as at least half of these spaces are filled with energy accumulation composition, and a T-shaped three-flat corner is filled with external vertical transparent layer (5), and the other two layers (1-a), and (7) are dense, such as in the layer (7) shaped the first vertical zigzag channel (7-a); and the second horizontal zigzag channel (7-b), as in the channel (7-a) is a heirloom layer (6), and Zig Zag shaped element (6) is fixed to the thick layer (7) with the connector (4)as in the sewers (7-a) and behind this layer (6) are located in the thin heating coils (3-b), and to the same layer (6) are located on the thicker heating coils (23), such as

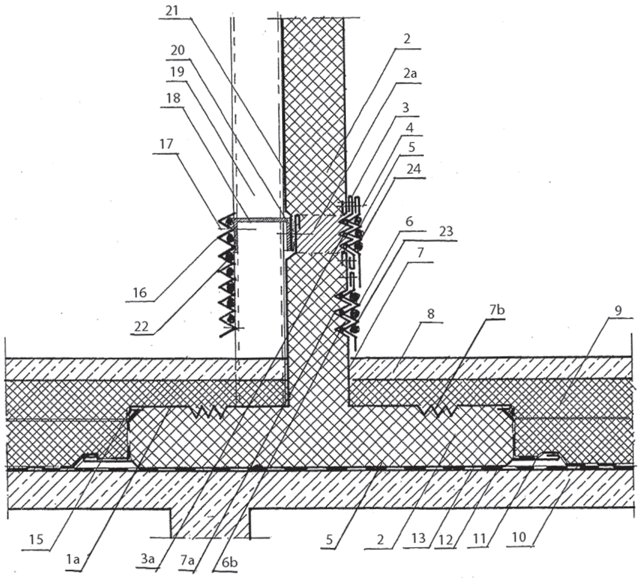

Fig. 7. Refrigerator for fruits and vegetables. „T”-shaped joint. „System for solar heating of cooling chamber with positive temperatures” BG111658 (A)
(Aleksandrov, 2013b)
(1-a) external transparent layer; (2) transparent thermal insulation; (3-b) thin heating coils;(4), (17) connector; (5) “T”-shaped three-flat corner; (6) zig-zag shaped element; (7) inner dense layer; (7-a) first vertical zigzag channel; (7-b) second horizontal zigzag channel; (21) external vertical transparent layer; (23) thicker heating coils

to the left of the layer (1-a) are located other vertical curved channels (7-b), and the two flat corner (on the external walls of the enclosure) is filled with outdoor transparent layer (1-a), the inner dense layer (7) as in layers (7) shaped the first vertical zigzag channel (7-a) and the second horizontal zigzag channel (7-b), as in the channel (7-a) is situated heir.

Membranes hung on tensegrity- structures and structures suitable to protect cameras and volumes in extreme situations

7 struts; Kenneth Snelson. Mesh Bag with 7 struts by Snelson (Figure 8)

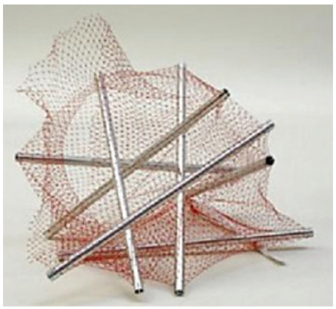

Fig. 8. Mesh bag containing 7 tubes, by Kenneth Snelson. The refrigerators for fruits and vegetables can be located under the net of the sack
(Kenneth Snelson, 2016a)

Kenneth Snelson put bars Snelson, Kenneth in a bag, forming a mesh bag tensegrity. One photo published on the web features 7 struts.

12 struts. Models and Examples
Kenneth Snelson 12 Strut Model (Figure 9)

Fig. 9. Kenneth Snelson. Supporting 12-haired props cube, which can be located chambers or volumes for operation in extreme situations
(Kenneth Snelson, 2016b)

„Kenneth Snelson constructed a series of four tensegrity structures that metamorphose slowly from evoking a truncated octahedron to evoking a truncated cube. Each model features 12 struts in a new arragement” (Kenneth Snelson, 2016b).

The refrigerators for fruits and vegetables are mobile and built two parallel paths having two ramps and horizontal part are inserted into the tunnel operating at risk of extreme situations – 270 struts**.** Table of Contents.

270 Strut Sphere by Leftwich
Links and References (Figure 10)

„Jim Leftwich posted details of his 270 strut model to the Well. It was constructed with wooden dowels and nylon thread. The colored hairbands wre added last, as an additional method to hold the nylon tendons in place” (Jim Leftwich, 2016.) Hemispheres can also be used for covering large areas; in such areas inside them can be placed refrigerators for fruits and vegetables, which also can be used in extreme situations (Figure 10).

Others solutions (Figure 11-16)

Volumes are protected from direct external influences: acid rain, volcanic ash, solar radiation; it is appropriate volumes to be sealed ie filled with gas-tight connections between the panels of the walls and ceiling (Figure 11).

A membrane consisting of a peripheral shoulder loop, reinforced by transverse ribs and consoles protruding from the contour; between the loop and the ribs are stabilizing horizontal hinge- batters. Wear shoulder contour of vertical columns connected by a vertical contour payanti- batters;

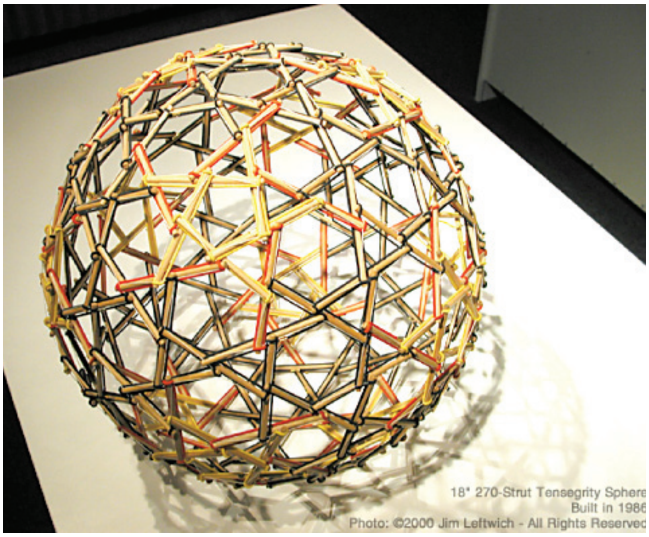

Fig. 10. 270-strut tensegrity sphere by Jim Leftwich
(Jim Leftwich, 2016)

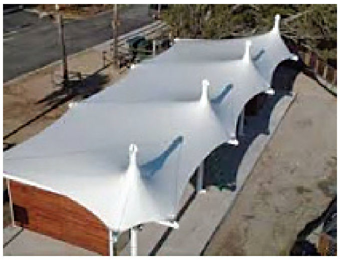

**Fig. 11. Arranged refrigerators for fruits and vegetables under tight membrane **
(2016, Homecolorides, info)

on three sides of the structure diagonals stabilize columns against hinge horrizontal forces of wind; front between columns can be inserted chambers or volumes under the membrane (Figure 12).

The skin of the wings of a butterfly in the open position, as a prototype of modern membrane (Figure 14). The fibers of the skin are ropes stretched on supporting contour worn by columns. Another version – skin is stretched over the tops of the tensegrity structure that is self-supporting (Figure 15,

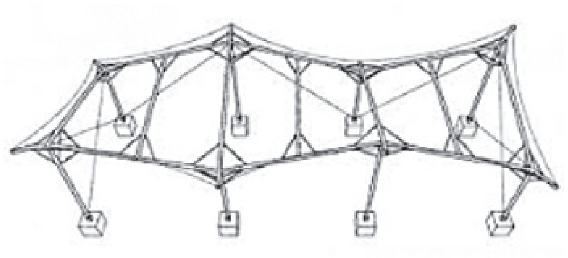

Fig. 12. Overall structure of the transparent membrane
(2016a secure.ifai.com)

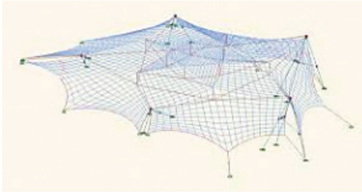

Fig. 13. Membrane
(2016b www- research. cege.ucl.)

Fig. 14. Butterfly
(2016. en.wikipedia.org)

Fig. 15. Arrangement of refrigerators for fruits and vegetables. A stretched membrane suspended by the supporting structure
(2016a. secure.ifai.com)

Fig. 16. Space formed under the stretched membrane of tensegrity-structure suitable for placement of refrigerators for fruits and vegetables for medical purposes
(2016a.secure.ifai.com)

16.) Network membrane stretched over supporting elements seen ropes and belts (Figure 13).

Discussion

All three solutions with inventive step allow the construction of refrigerators for fruits and vegetables, whereas solar energy is a decisive factor ensuring the achievement of positive temperatures according to the respective technological regimes. The integration of transparent elements in the structures of the walls and the roof of the refrigerators increases considerably the possibilities for their use in extreme situations, for instance for medical purposes. This construction not only allows the penetration of natural light but also creates the conditions necessary in order to maintain a constant positive temperature inside.

In extreme situations a secondary hothouse effect occurs if the refrigerators for fruit and vegetables are situated under transparent membranes, suspended over tensegrity-structures.

In the case of symmetrical transverse sections (Figure 9) of the tensegrity-structures ramps can be used to ensure access to the refrigerators for fruits and vegetables, whereas they can either be inserted into the space of the tensegrity-structure or placed in natural pits, hollows, etc. where also parts of the tensegrity-structure are situated. Thus, the effects of wind pressure and blasts can be considerably reduced.

Conclusions

In extreme situations the chambers and volumes should have a universal purpose. The technical solution of the supporting structure and building envelope should allow the integrated use of the internal space of the volumes for different functions. Ensuring a high level of assembly capability, combined with opportunities for quick disassembly of the volumes will allow greater operational flexibility, with options for relocating the volumes to different territories. The use of air-tight materials in the structure of the links between the elements of the volume will allow their use for protecting in terms of bacteriological pollution, at high levels of radon-gas, where its separation can be induced as a result of displacement of the earth layers after earthquakes and others (Patent BG63644 (B1) – Built-up refrigeration chamber) (Aleksandrov, 2002).

The sealed enclosure for positive temperatures, for storing fruits in an air contaminated environment can be used for medical purposes, for example, operating rooms and operating units, as long as the square surface can fit in the square surface of the chambers. Their temperature of +2 to + 8°C is ensured by the greenhouse effect, which is obtained after the direct penetration of sunlight into the rooms. (Application of the patent BG111651 (A). Moveable cold storage chamber for positive temperature) (Aleksandrov, 2013a).

A positive temperature of 22 – 24°C required for the operating rooms, for example, is achieved with the help of solar energy, air or water collectors located on the roof of the volumes and included as components of the solar systems for heating water or air. (Application of the patent BG111658 (A) – System for solar heating of cooling chamber with positive temperatures) (Aleksandrov, 2013b).

The glazing of the sealed volumes will allow the penetration of natural light, which is essential for the operation of their internal spaces during the day after the occurrence of the devastating impact caused by the effects of the extreme situation.

Membranes stretched over tensegrit-structures allow achievement of modern architecture in extreme situations, and with possible solutions and specific functional requirements associated with the answer to the refrigeratory – technology and specific medical requirements (Kenneth Snelson, 2016a, Kenneth Snelson, 2016b,. Jim Leftwich, 2016).

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