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Engineering

New Closed and Open, Transformable Pantographic Rod Structures Designed on Single and Double Curvature Surfaces

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In this paper we report on new designs of transformable structures on cylindrical, conical and double-curvature surfaces. The presented geometrical layouts are structural designs of closed- and open-loop deployable structures. The transformable designs are made by an interconnected set of elementary pantographic structure. The elementary transformable structure consists of two levers connected by a transverse cylindrical joint. The considered designs of transformable structures can be effectively used in both space structures, in particular deployable space reflectors and ground-based transformable structures. The results of testing the structures showed the advantage of application of the new model. *© 2023 Bull. Georg. Natl. Acad. Sci.*

pantographic structure, cylindrical joint, transformable constructions, deployable installation, space-base system

Transformable constructions made of pantographic structures, with a circular or oval outline, are used in deployable installations, both on earth and in space-base engineering systems.

The round or oval transformable pantographic structures are used to deploy a space reflector and fix its shape [1-5].

A model using a pantographic structure with pantograph levers with a circular section that were connected to each other in their top and bottom assemblies with one cylindrical joint was fabricated in 1979. The joint axis was oriented towards the center of the sphere, the radius of which was equal to the radius of the circumcircle on the chord of the levers.

The work in this field was continued and was reflected in the work carried out by the Institute of Constructions, Special Systems and Engineering Maintenance of Georgian Technical University and the European Space Agency in 2010-2015 [5].

The expansion ring design is based on a single-row pantograph, whose intersecting longitudinal elements are arc-shaped. They are connected only by one cylindrical joint at the points of intersection and connection.

The complete design of the structure is a truss frame, in which the central rod is presented by pantographic elements and the flexible prestressed elements are: a flexible prestressed belt, a technological flexible prestressed belt and flexible preformed trusses.

This system is very convenient and its accuracy is achieved by adjusting the length of the flexible elements without fixation clearances.

The flexible elements are prestressed at the expense of the ring deployment with pantographic elements.

If adding a technological mesh with triangular cells, a reflective mesh to the complete design of the expansion ring and equipping them with strainers by fixing them into the technological mesh with a desirable shape provided by means of technological radial ropes, the reflector structure is obtained.

The scheme presented in [5] served as the basis for the model designed by doctoral student Revaz Sakhvadze, 108 model assemblies is introduced as a scientific novelty [6].

In 2018 "EOS Data Analytics Inc." established "Transformable Structures Georgia – T.S. Georgia LLC" in Georgia. The new company designed the structures with their design based on transformable pantographs construed on single and double curvature surfaces. The works are confidential.

At this stage, by considering the future prospects of the company, based on the works and concrete publications of Georgian School of Space Technologies [7], a new class of transformable structures is designed. The basis for their design is the designs developed by us, which correspond to the principles of arch geometry.

Below are the diagrams of transformation of the structural designs (Fig. 1-9):

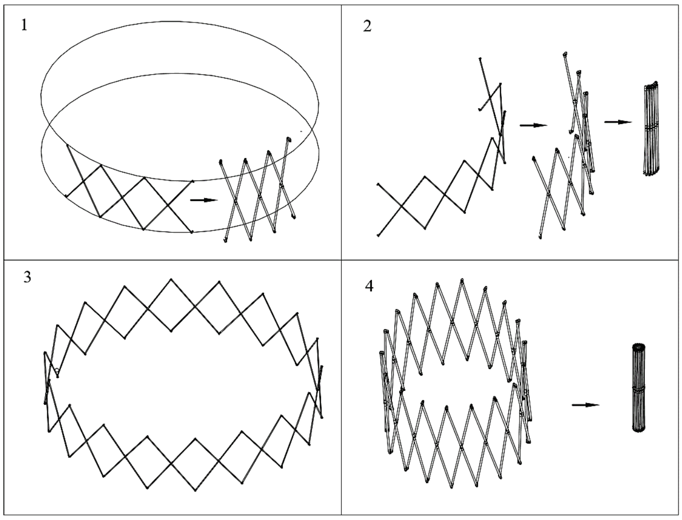

Fig. 1. Simple transformable pantographic structure construed on the lateral surface of a circular cylinder in four stages of structural development.

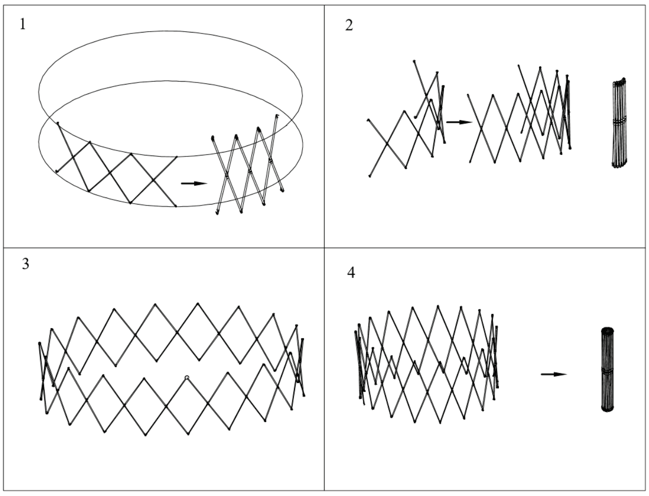

Fig. 2. Simple transformable pantographic structure construed on the lateral surface of an elliptic cylinder in four stages of structure development.

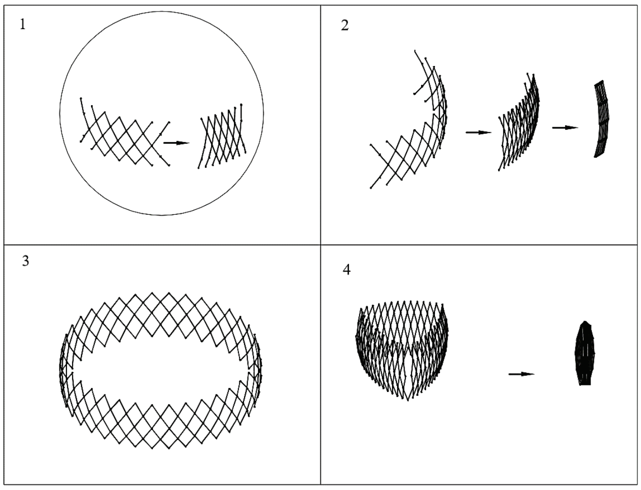

Fig. 3. Complex symmetrical transformable pantographic structure construed on the surface of a sphere in four stages of structure development.

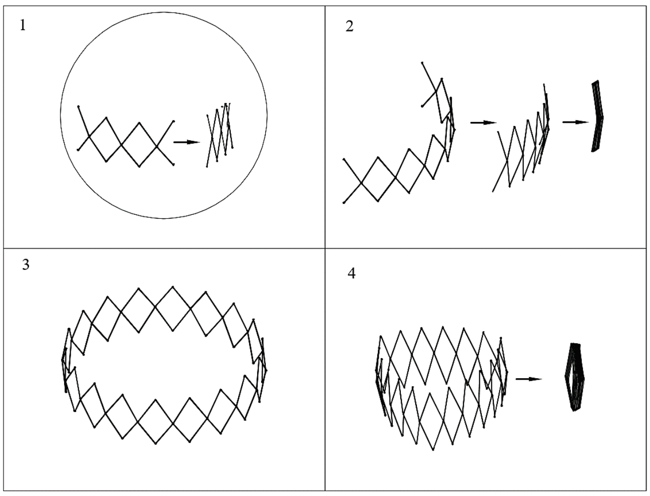

Fig. 4. Complex assymetrical transformable pantographic structure construed on the surface of a sphere in four stages of structure development.

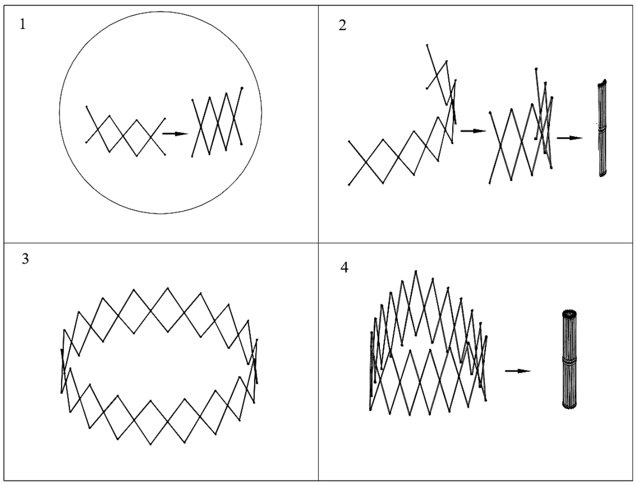

Fig. 5. Simple transformable pantographic structure in four stages of structure development, construed on the surface of a sphere, when the ends of the pantograph levers are on the surface of the sphere.

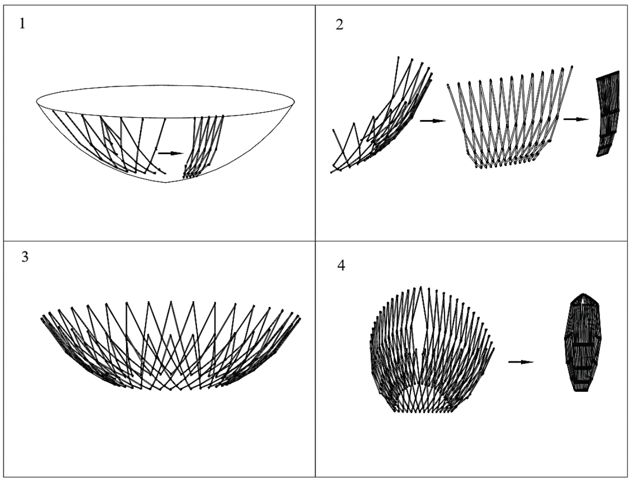

Fig. 6. Simple transformable pantographic structure in four stages of structure development construed on the surface of a sphere, when the ends of the pantograph levers and the central assembly of their intersection are located on the surface of the sphere.

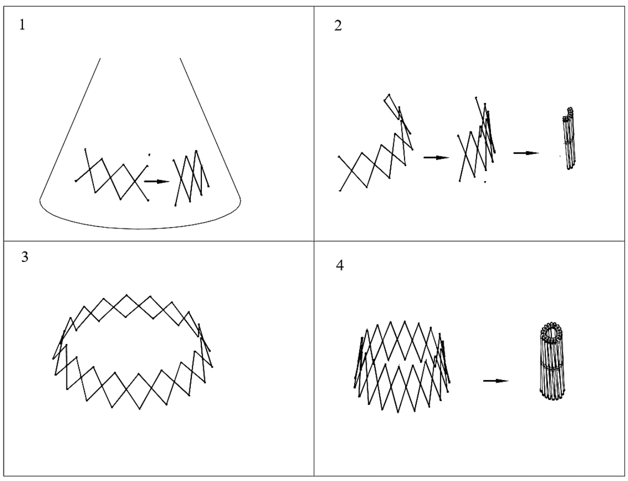

Fig. 7. Simple transformable pantographic structure in four stages of structure development construed on the lateral side of a cone.

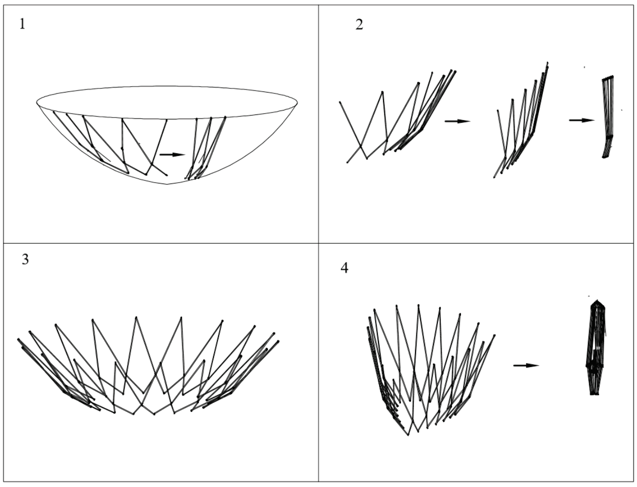

Fig. 8. Simple asymmetrical transformable pantographic structure on the sphere in four stages of structure development.

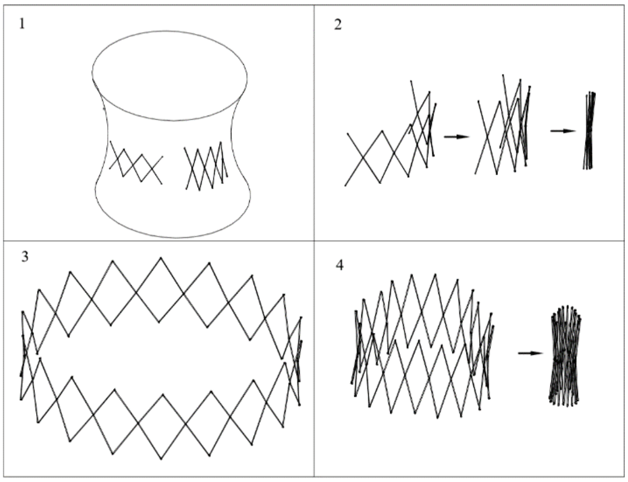

Fig. 9. Complex transformable pantographic structure construed in four stages of structure development on the surface of hyperboloid.

Concrete patent-protected designs are developed according to each diagram.

ინჟინერია

ერთმაგი და ორმაგი სიმრუდის ზედაპირზე ახალაგებული, ჩაკეტილი და გახსნილი, ტრანსფორმირებადი, ღეროვანი, პანტოგრაფული სტრუქტურები

ე. მეძმარიაშვილი

აკადემიის წევრი, საქართველოს ტექნიკური უნივერსიტეტი, ნაგებობების, სპეციალური სისტემებისა და საინჟინრო უზრუნველყოფის ინსტიტუტი; კომპანია „ტრანსფორმირებადი ნაგებობები. საქართველო“, თბილისი, საქართველო

ნაშრომში განხილულია ახალი ტრანსფორმირებადი კონსტრუქციების შექმნის შესაძლებლობები ცილინდრულ, კონუსურ და ორმაგი სიმრუდის ზედაპირზე. წარმოდგენილი გეომეტრიული სქემები შეესაბამება ჩაკეტილი და გახსნილი კონტურის გასაშლელ-დასაკეცი კონსტრუქციების სტრუქტურულ სქემებს. მოცემულ კონკრეტულ შემთხვევაში ტრანსფორმირებადი კონსტრუქციული სქემები აგებულია ელემენტარული პანტოგრაფული სტრუქტურის ურთიერთდაკავშირებული სიმრავლით. ელემენტარული ტრანსფორმირებადი სტრუქტურა შედგება ჯვარედინად, ცილინდრული სახსრით დაკავშირებული ორი ბერკეტისგან. განხილული სქემების გამოყენება ტრანსფორმირებად კონსტრუქციებში ეფექტურია როგორც კოსმოსურ ნაგებობებში, კონკრეტულად კი გასაშლელ კოსმოსურ რეფლექტორებში, ისე მიწისზედა ტრანსფორმირებად კონსტრუქციებში.

REFERENCES

1. Medzmariashvili E., Tserodze Sh., Santiago-Provald J., Medzmariashvili N., Tsignadze N. (2015) Mechanical support ring structure. European Patent N: EP 2825827 A1.
2. Medzmariashvili E., Tserodze Sh., Santiago-Provald J., Medzmariashvili N., Tsignadze N. (2015) Mechanical support ring structure. USA Patent - Patent N: US 9153860 B2.
3. Medzmariashvili E., Tserodze Sh., Santiago-Provald J., Medzmariashvili N., Tsignadze N. (2016) Deployable antenna frame. European Patent N: EP2904662 B1.
4. Medzmariashvili E., Tserodze Sh., Santiago-Provald J., Medzmariashvili N., Tsignadze N. (2017) Deployable antenna frame. USA Patent - Patent N: US 9660351 B2.
5. Medzmariashvili E. (2013) Technical assessment of large deployable structures (TALDES) antenna reflectors baseline desines description, Issue 1, Ref.: TN 1.1.2-TUM/GTU-13/01/11-07D-1 SOW: TEC-MSS/2010/84/ln/JSP Page CCXVIII of 218.
6. Revaz Sakhvadze (2023) Creation of the Aerospace Defence System in Georgia by improving the tactical and technical parameters of orbital complex. Candidate Thesis. Scientific advisors: E. Medzmariashvili and T. Khmelidze. Georgian Technical University.
7. Gogilashvili V., Medzmariashvili E., Tserodze Sh., Sanikidze M., Tsignadze N. (2009) Advanced lightweight structures and reflector antennas. Structure and kinematical synthesis of transformed systems mechanisms, *Proceedings,* pp. 117-126. Tbilisi, Georgia.

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