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32

INFLATABLE STRUCTURES IN SPACE

By Col.-Engineer A. Kozorezov and
L/Col.-Engineer A. Glukharev

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By Joseph L. Zygielbaum, Data Dynamics, Incorporated
Los Angeles, California

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The modern scientific mind considers the construction of manned space stations in orbit and the landing of man on the nearest planets as very much realistic. For this reason, scientists and engineers show great interest in the problem of how to transport bulky and cumbersome spacecraft contained within the limited capacities of rockets.

The best solution to this problem, as seen by foreign specialists, is in the broad application of inflatable structures.

Inflatable structures are made of flexible material. As the material is filled with gas, it takes on the necessary form, and it resists the effect of external loads by means of the excessive pressure which developed within the structure.

Such structures are already being used in various areas of technology and engineering including flying machines--dirigibles, automatic aerostats, and inflatable aircraft.

It is now proposed that inflatable structures might be used successfully in the development of manned, as well as unmanned, spacecraft. Particular consideration is given to the possibility of applying inflatable structures in systems designed for the rescue of astronauts, as well as the instrumentation of spaceships.

Inflatable systems must be of a minimum weight and size in their initial (folded) position. Therefore the selection of the material and the form of the construction are of the highest magnitude of importance. This would secure the economic utilization of the working area of the container of the carrier rocket.

Polymer cloth of the polyethylene type, polypropylene and other

CR-92596
Page 6
Code 1
Cat 32

materials are very promising for achieving a low weight. These materials have a small specific weight and considerable durability (particularly mylar).

An application might be found in inflatable structures designed for manned flights with a re-entry into the dense layers of the atmosphere, using single and multi-layered, diagonally-doubled fabrics made of natural as well as synthetic cloths such as nylon, kapron, fortizon, dacron, etc.

The selection of material depends on the designation of the spacecraft and the conditions of its exploitation. Thus, for structures designed for manned orbital flights, materials of particular durability are necessary. In other cases, requirements of lesser magnitude might be placed on the material. However, in all cases the materials must have a very low permeability to gas.

Inflatable structures and their units are normally constructed in the form of the simplest geometrical figures: cylinders, spheres, and tores (Figure 1), or a combination of these. This makes it possible to use thin, flexible material and to develop compact structures which are convenient for packing into small areas of the containers of carrier rockets.

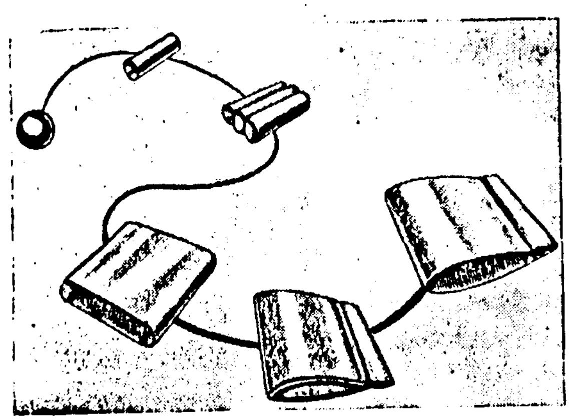

Fig. 1. Shapes of inflatable structures.

An inflatable structure must take on the designated form in a very reliable manner. This depends very much on the method of the structure's unfolding after ejection from the container of the rocket or a special packing box in which it was stored during the flight.

In the proposed structures, inflation is accomplished either by the energy of gas (air) left within the inflatable structure or by the energy of gas which is emitted by special reagents located with the structure.

Fig. 2. Servicing of inflatable structures by astronauts (proposed appearance).

The selection of an inflation method is dictated, first of all, by the designation of the structure and the conditions of its exploitation. It is expedient to apply the first method, particularly in the case when rapid inflation is required in order to give the structure its assigned shape. The second method can be applied when the working area of the structure is sufficiently large.

Of not less importance is the task to secure the preservation of the shape of the inflatable structure over a prolonged period of time. For this purpose are used special coverings which are sprayed on the internal or external surface of the structure. After hardening these covers secure the required shape.

Attention is paid to the problem of the tenacity of an inflatable structure during collisions with micrometeorites.

According to data published in the foreign press, a sphere with a diameter of 15 meters at an altitude of approximately 1,500 kilometers might receive one puncture measuring 0.25 centimeters in diameter during a period of one month, as a result of collisions with meteorites. An automatic resealing of punctures, for instance by means of injecting rapidly hardening liquids into the specific section of the inflatable structure where a drop in pressure takes place, is provided for such a case. In Figure 2 is shown another method for repairing inflatable structures by astronauts in the course of their extravehicular examination of the craft.

We shall examine several projects. Let us take, for instance, an inflatable space station/laboratory designed for a prolonged flight in orbit with a crew of astronauts on board (Figure 3).

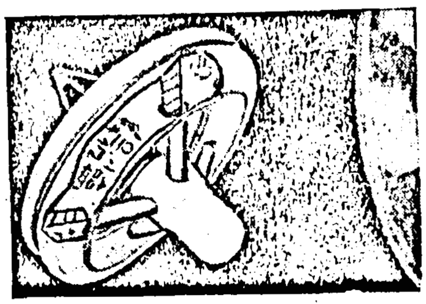

Fig. 3. Design of an inflatable orbiting station.

The design of such a station, which has the form of a tore, consists of a combination of rigid and inflatable elements. Six rigid cylinders are connected by sections. A rigid cylindrical hub is connected to the tore by three inflatable spokes which give access to the rigid cylinders. The station rotates around its hub for the purpose of creating artificial gravity. Thanks to the large diameter of the tore (36 - 45 meters) the speed of rotation necessary to create such gravity is not large. Such elements of the station as, for instance, a solar collector, floors, and furniture are also proposed to be constructed in the form of inflatable structures.

Inflatable apparatus designed for the return of the crew to Earth is provided on board the station. Before launching, the station will be stored in the nose section of the carrier rocket. In orbit the station will deploy automatically and become inflated.

A simpler inflatable spacecraft is presented in Figure 4. It is proposed to take such a space station on board one of the "Gemini" spaceships.

The inflatable station (pictured in center) will take on the form of a cylinder with a diameter of 3 meters and a length of 7.6 meters. The walls of the station will be fabricated from laminated material and fortified by solidifying polymers which will add rigidity to the structure.

The passive communication satellites of the "Echo" type are another example of an inflatable structure. Spacecraft of such a type might be prepared in the form of a single-unit inflatable structure.

The American press in particular has reported the launching of a satellite which carried a folded inflatable envelope in its nose section. In a circular orbit at an altitude of approximately 1,000 kilometers, the envelope was supposed to have separated from the satellite and become inflated with gas. This structure consisted of a wire-mesh body covered by a special material. In the conditions of a vacuum the material should have become evaporated under the influence of the ultraviolet radiation of the Sun and the remaining sphere-shaped body, measuring nine meters in diameter, would be used in the capacity of a passive communication satellite.

The Federal Republic of Germany is also developing an inflatable satellite for a complex of scientific investigations. All sections and elements of this satellite are planned to be constructed of inflatable materials combined with rigid bodies.

Inflatable structures might also find a broad application in spacecraft designed for re-entry into the dense layers of the atmosphere. It is proposed to use such spacecraft for the return of crew members of space stations and also for the rescue of elements of spaceships. Such a flying apparatus will take on its required form by means of gas (for instance, helium) which the spaceship will inject into it. Special jet motors will be used for navigation through space. During the entry into the dense layers of the atmosphere, deceleration of the spacecraft will be accomplished by inflatable elements of large dimensions, due to the formation of a lifting force. From then on, the spacecraft will glide through the atmosphere and will accomplish a "dirigible" landing, i.e. by releasing gas.

The use of inflatable wing-parachutes is proposed for the rescue of parts and elements of spaceships.

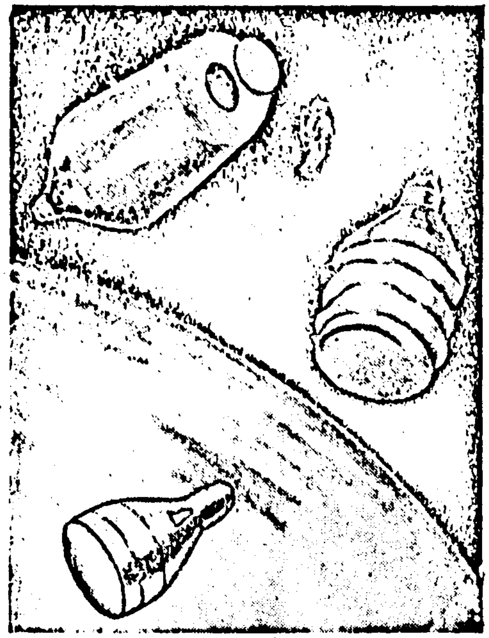

Fig. 4. Inflatable structure released by a "Gemini" capsule (proposed shape).

Astronautics has already acquired a certain practical experience in the use of inflatable structures. In spite of the complexity of problems related to the development of such craft, the advantages of such structures are indisputable in the opinion of foreign specialists, and further application of such structures will undoubtedly be found. We have in perspective the development of spacecraft of various designations.