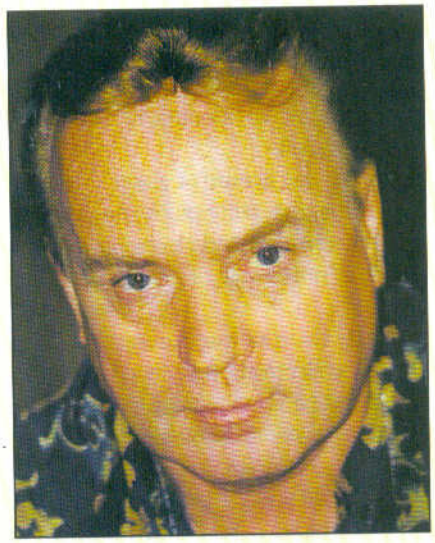
ELASTIC MACHINES AND MECHANISMS OF THE FUTURE

Elastic Engineering (ELASTONEERING®) is a new trend in engineering formed at the boundary of mathematics, mechanics, electronics, biology, bionics and chemistry. This innovation allows resolve the most complicated problems of mechanical actions, movements and displacements, which on the one hand require less energy being environmentally pure, and on the other hand have high efficiency and power. The products of this technology will have application in all human spheres: from handlers to robots, from noiseless power elevators, efficient load-lifting mechanisms to light machines with super passability, from rescue mechanisms to military equipment, from individual to gigantic natural energy converters.



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History shows that any civilization sooner or later faces its own crisis, which is good for progress as a whole and bad for contemporaries. Even Chinese wise men did not advise to live in the era of changes. Our civilization is facing such a crisis now. With one leg (e.g. information technologies) it has entered the 21st century, whereas with the other leg it is ... neither in the 20th nor in the 19th centuries. This retarded leg in our civilization is known as traditional mechanics whose principal laws were formulated several centuries ago.

Mecanical dog electronic infarction.

Let us use for example, "a dog" designed and made by the methods of traditional mechanics and electronics. The bearing and moving apparatus of our "dog" is made of multi-link mechanisms with numerous sensors and actuators attached, power and information cables are connected to control systems, and various energy converters feed the brain, the digestive tract etc. The control system, the digestive tract, the lungs and energy converters are located outside the body, otherwise the "dog" would not be able to move forward or would get an infarction after the first step. Thus our "dog" consists of two independent parts: mechanical and electronic that physically do not belong to one structure. Moreover, the coordination of their actions will require unjustified material and energy costs.

The brightest (flagrant) example of a machine based on traditional mechanics and electronics is the anthropoid robot which "eats up" unjustifiably large amounts of material and financial resources required for its development, manufacture and operation. It is not clear why such anthropomorphous robots do not resemble a snake, a dog, a rat, a squid or peristalsis-like species , or why they do not move on wheels. Non-human robots should definitely possess the best technical and economic features and elements copied from Nature.

The hopeless situation is aggravated by the absence of alternative sources for generating the necessary quantities of atomic energy, the atomic energy sources which are similar to nuclear weapons in their destructive effect and spontaneous functioning as well as the limited oil, gas and coal reserves. This leads to energy crises, to efforts targeted at establishing quotas for oil extraction, international conflicts which confidently and inevitably pave the way to a global crisis, and the loss of control over parameters regulating the fragile nuclear World.

Thus, it is necessary to find solutions allowing:

1) the conversion of "inexhaustible" and "free" energy of the sun, wind, waves, tides and the pressure differential of the air and ocean space;

2) the reduction of hydrocarbon fuel consumption by 10%-70%.

One of the solutions is Elastic Engineering (ELASTONEERINGr) that has such natural analogues as peristalsis characterized by highly efficient work, coordinated with the action of the digestive tract muscles of a living organism or such global phenomena as waves, wind, and pressure differentials in the ocean and space.

Specific properties of elastic engineering

1) The mechanical and electronic systems of a machine or mechanism are formed as one physical structure performing mutually coordinated functions.

2) The conversion of energy into motion, one type of motion into other ones is a single unit mechanism, that performs the same functions as the multi-unit mechanisms in traditional mechanics.

3) The basic constructive element of elastic machines and mechanisms is the

elastic shell (membrane) filled with a fluid (working) medium. In an elastic machine or mechanism the main function of the shell (membrane) is a continuous search of its equally stressed state under the influence of the external and/or internal forces.

4) The electronic system of a mechanism is formed directly in the structure of the shell material (elastic electronics) and/or the fluid medium enveloped in the shell (membrane) and/or constructional elements kinetically connected with the shell.

5) The key feature of elastic engineering is the possibility of creating entirely new mechanical and electronic systems, such as novel soft or elastic radio-elements.

Today there are various solutions as to how the electronic and mechanical systems can be combined in a machine to economize the technological and household space, to improve the consumer goods quality etc. These are soft electric heaters, band power and information cables, current-conductive rubber production, elastic thermal conductive insulators, many-layer polymer material for storing holography data, antenna ultra-high and high frequency band irradiators, semiconductor displays made of hybrid, organic and inorganic materials, "rag" solar batteries: a"jacket" made of synthetic fiber, which generates electric current under the impact of light. These innovations, however, have nothing to do with elastic engineering.

The simplest membrane/shell-based elastic mechanics elements which permit to use the fluid medium properties, those of the soft and elastic shell materials as well as the classical mechanics elements have existed for a long time now. These are pneumatic casing (soft casing), soft and elastic shells/membranes-based air-supported constructions,soft bearing shells for hydraulic works (dams, watergates etc.), lenient shells capable of shape-changing (ship hull's parts, containers, jacks, inflatable boats etc.); air vehicles (soft balloons and balloons).

The elastic machines and mechanisms advantages

- The possibility of creating new, no-step types of movement intrinsic to the fluid medium, the shell and the construction elements kinetically connected with the shell, i.e., the takeoff, the floating, the streaming, the non-rectilinear direction motion, theenveloping, the unscrewing, the pulsing, the wave-like motion, the swinging along and crosswise the revolution axis, the folding in dense volume, the telescopic arrangement etc.;
- The shell can have big dimensional capabilities of diameter and length: from the proportion of millimeters to tens, hundreds of meters.
- The shell can be used as a consumable within devices and mechanisms.
- The requested functions can be realized by task-oriented software.
- The high efficiency — the energy of the fluid (working) medium, enveloped in the elastic shell, is converted into motion and, consequently, the sliding friction is replaced by the rolling friction, thus providing a "wheel" effect.
- The low power and material consumption — the "rigid" construction materials are replaced by the elastic construction materials of the shells.
- Mobile, easy to operateand repair, assemble and dismantle, particularly in extreme conditions.
- The high degree of the construction elements universal properties.
- The no-step control and smooth adjustment.
- Universal application.
- Minimal mass and small size (during storage)
- Environmentally pure and friendly.
- Silent operation.
- The lack of necessity to organize new special manufactures.

Magic bubbles

The concept of a "shell" is the base for building elastic machines and mechanisms.

One of the best known natural constructions is a shell. Unicellular and multicellular creatures are enveloped in an elastic film-shell. Muscles are a bunch of fibers covered with a film, which is subjected to the blood pressure like any closed shell subjected to the gas or liquid pressure. Our earth, the solar system and galaxy are enveloped in an invisible protective coating. The vortex motion of gases and liquids, for instance, the atmospheric cyclones with diameters of several thousand kilometers are also wrapped in invisible cover-zones, or fields of force with equally stressed surfaces. It is also important that the material structure of such shells contains an electronic system, namely, the information and power links, the sensors and actuators, the invisible data processing centers that not only support the existence of such phenomena (statics), but provide an optimal movement in the environment (dynamics) with minimum energy expenditure.

The classical physical model of a shell structure is a soap bubble used to study the properties of gases, liquids and crystals. It is chosen as a physical model of an elastic toroidal shell filled up with such a fluid (working) medium like gas and having five degrees of freedom to move over

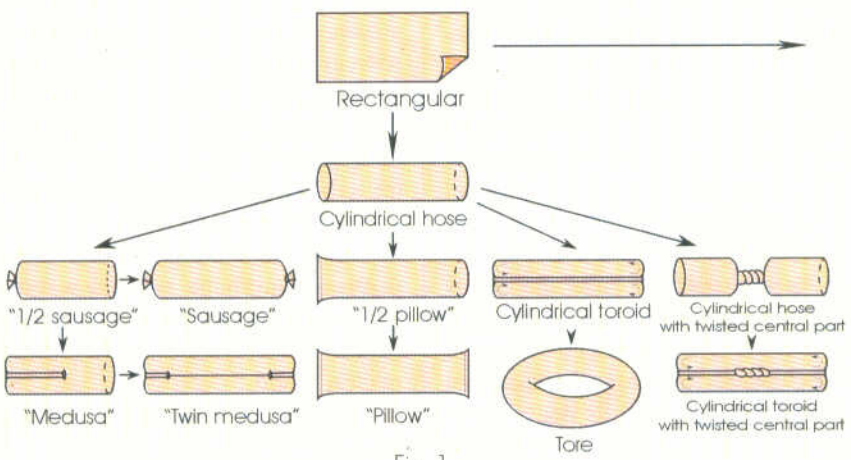


Fig. 1
Estimated technological Cutting Plan of Spatial Planes of Flat Billet

three axes of travel and around two axes of rotation.

In order to define the stressed states of the stress concentration areas, the probable places of the construction break and the possible shell folds-formation areas, the mathematical model of a soap bubble is used, namely Kassini's ovals whose rotation planes imitate various distorted forms of the shells.

The elastic shell,unlike the thin rigid shells works only when it is under the excessive pressure of the fluid (working) medium, which defines the energy properties of the system (the shell being a working medium); its geometry and shape change under loading. The shell itself does not have any shape, its material at the limit is absolutely thin, strong, non extensible, elastic and weightless.

Let us study some types and forms of the shells that can be practically used from the point of view of their design features and sequential transformation or deformation in operation (Fig.1). The topological approach in the classification of elastic shells requires complementary constraint related to allowed design transformations.

Based on the above mentioned, it is suggested to apply to the shells of elastic engineering the n-dimensional, e.g. three-dimensional topological and geometrical and/or topological and functional classification that for each shell there are compatible topological properties of its surface and functionality appearing as geometric constraint. The result of this classification accounting for such necessary features as material, control system, application, role in the layout diagram has become the n-dimensional Table, a kind of "Periodic System" of elastic machines and mechanisms — Shikhirine's system.

It should be noted that due to its specific nature the elastic shell can acquire many various shapes under the impact of the internal and external forces, the topological cohesion remaining unchanged, all the shapes being homeomorphic, whereas the metric characteristics do change due to the formation of folds in the non-stressed zones.

Such characteristics make it extremely difficult to describe mathematically the formation and transformation of a loaded surface in the system "shell-working medium", to use the traditional bulky differential mathematical apparatus, thus modelling being required.

In order to obtain a physical and later a mathematical model it was necessary to clarify the initial conditions of the loaded elastic shells existence.

This refers primarily to the working medium, and further the shell:

1. The medium is discontinuous, the shell is a single whole!

2. The working gas is real, the intermolecular interaction of the working gas particles is significant!

3. Under the intermolecular forces and the compressed air pressure forces fields are created which form the stress in the shell locking the working medium.

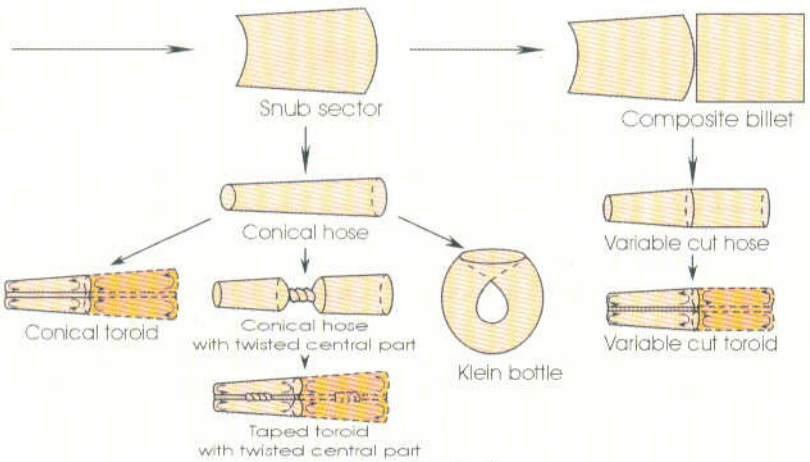


Fig. 1 (continiation)
Estimated technological Cutting Plan of Spatial Planes of Flat Billet

4. The sphere-like field as well as the equipotential stress surface field are equally stressed.

5. The pattern of forming an electric force field similar to a medium force pressure field in an enclosed space should become the basis for the elastic shell stress mechanism.

Kinematically active elastic toroidal shells

The elastic toroidal shells filled with the fluid (working) medium are the toroids kinetically connected to such construction elements as the central and/or external, and /or internal peripheral bodies. The mechanisms and machines made on this base are called the tore technologies — TORTECHr and are more interesting from the point of view of their practical application.

The shell filled with the fluid (working) medium under normal or excessive pressure can take various shapes, for example, that of a toroid — a closed tore of the non-circular section, whose surface is formed by the rotation of the second or forth order plane curve around the axis of symmetry.

Under the external and/or internal forces influence the toroid has the following functional features:

— Moves by means of unscrewing (eversion) or enveloping along a rigid or elastic support surface "flowing around" its deformed parts and foreign inclusions. At the same time, it is self-sealed in the closed contact surface, covering its periphery ("finds its own self".)

— Provides a vast controlled contact area and small specific pressure over the bearing surface with the low pressure of the fluid medium in the shell.

— Creates pulling efforts and an impact effect;

— Converts various types of energy, e.g. progressive motion into rotary one;

— Grasps the object irrespective of its shape by enveloping (galling), holds it and /or transfers it within the tore under controlled enveloping force ("soft grasp").

— By unscrewing (eversion) pushes out the imbedded object at various initial velocity;

— By unscrewing (eversion) and/ or (galling) enveloping changes one steady state into another one;

— At the "break" point provides a hinged swing of at least one free end;

— During the unscrewing (eversion), the velocity of the central body is twice as large as the velocity of the tore toward its periphery. Whereas, at enveloping (galling) the velocity of periphery is twice as large as the velocity of the tore toward its central part.

— Moves in the transverse direction by swinging; etc.

Materials for new mechanics

The backbone of new mechanics is the elastic intellectual (smart) material.

The key requirements for materials are impermeability, strength, and elasticity at minimum thickness and mass. The strength of the material depends on the properties of the reinforcing materials; whereas the environmental tolerance is guaranteed by, the polymer coating. Whatever the case, the elastic "smart" material used for the shell of an elastic machine or mechanism is constructional material. It should have uniform physical structure, including both the mechanical and electronic systems. At the same time it should retain its physical and mechanical properties when stretched.

Let us study the ideal construction material with a set of functions taking the example of the digestive tract of a human being and technique (Fig. 3, Table 1) and compare it with the idealized construction materials and functions used in radio-electronics and chemistry.

Using the peculiar features of the elastic toroidal membranes, it is possible to simulate the wavy peristalsis movement implementing the food displacement and mixing. On the basis of the unscrewing elastic toroidal shells it is possible to simulate sphincters whose relaxation and contraction allow a soft grasp and pushing out of the digested food to the other section of the digestive tract and the separation of the media between them.

For example, the sphincter moves around the anus and evacuates the digested food from one environment to the other..

In the radio electronic industry there are modules or blocks of radio-electronic devices with printed circuit boards (PCB) of various designs, layout, assembly and methods of mounting the elements on their surface, various designs of radio electronic devices and/or their elements, which can be regarded as idealized building material.

The structure of such idealized material contains:

— The dielectric layer — on a thick film micro-assembly;

— The "interlayer" — interconnection (contact pads, metal opening and buried via, dead and buried micro junctions), for example on a PCB;

— The power layer — IC substrate, PCB;

— The protective layer — e.g. epoxy encapsulation of the "smart" layer.

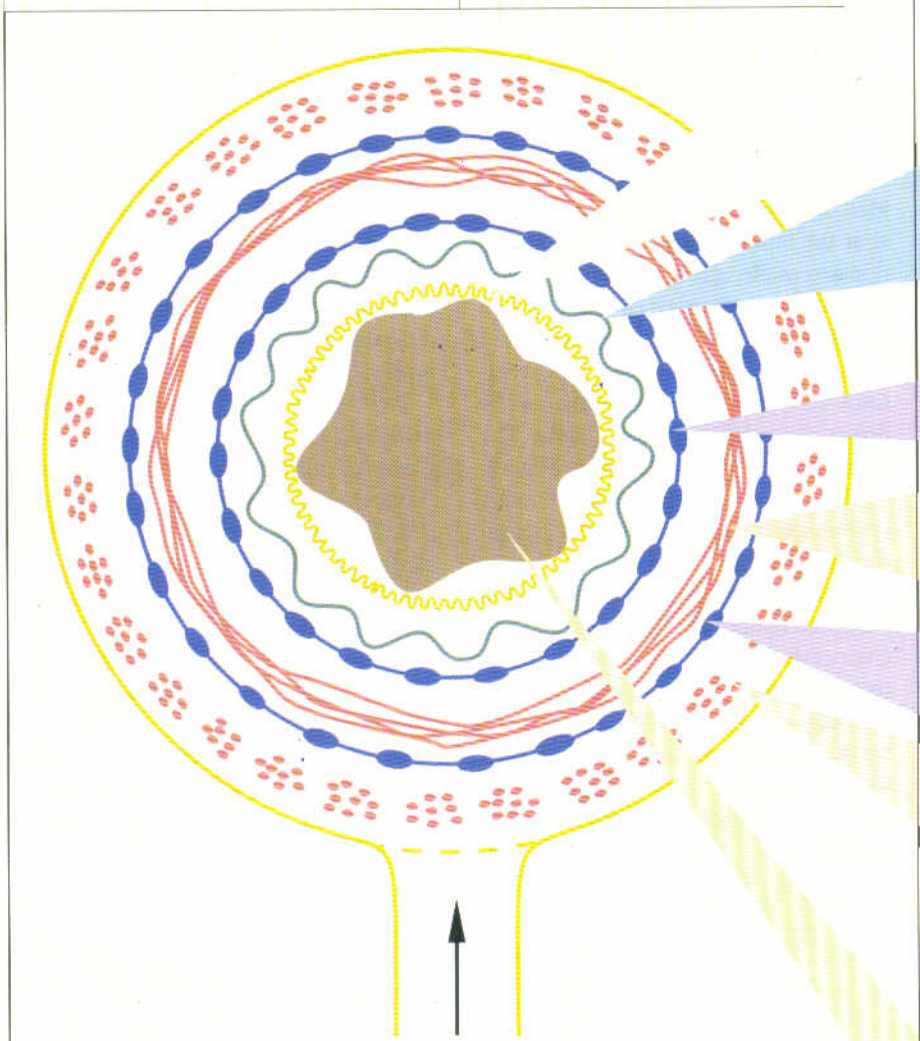


Fig. 3 Digestive Tract Layers.
Ideal Composite Material of Machine or Mechanism' s Elastic Shell

— The intellectual (smart) layer — electrical and radio elements including Integrated Circuits (IC);

— The conducting layer — power (display, power supply), data transfer canals on PCB, the conducting layer on the thick film micro-assembly;

— The resistive layer — on a thick film micro-assembly;

In the chemical industry there are composite film, cloth and film and other flexible, soft, elastic construction materials suitable for making a physically uniform layer as some idealized block or module of radio and electronic machines.

The ideal material structure embraces the following:

Table 1

#	Name	Biology		Technique	
		Composition	Functions	Functions	Composition
1.	Mucous Shell	Ferriferous epithelium with ducts for mucus and digestive ferments passage, connective tissue containing blood and lymphatic vessels.	Mucus secretion and food enveloping to ease the passage of food lump and protect walls of digestive tract against digestion with its own ferments. Secretion of digestive ferments for food lump splitting. Fastening of in the connective tissue of blood and lymphatic vessels.	Protective coating of elastic shell internal surface.Antifriction coating of elastic shell internal surface and the object embedded inside - this is the formation of elastic Container. Chemical action on an object, suction and replacement of liquid products along energy canals.	Internal layer of shell material consists of the first reinforcing layer with antifriction coating. Power communication canals, downstream and vacuum pumps for liquid displacement, sucking and pumping are attached in the interthread area thereof.
2.	Sub-Mucous base	Connective tissue made of *collagen and elastic* fibers, containing blood and lymphatic vessels, plexus nervosus and mucous glands.	The base of digestive tract and attachment of blood and lymphatic vessels and plexus nervosus. In its walls mucus secretion to mucous shell ducts.	Further displacement of chemical reaction products along energy canals. Antifriction coating generation.	The power layer of shell material. Control system, information and power canals are attached to the elastc frame. The first *independent* electronic system.
3.	Muscle base				Intellectual (smart) layer
3.1	Sub-Mucous, *Meissner's Plexus*	Plexus nervosus.	Regulates secretion of glands in the digestive tract wall.	Controls the formation of necessary product's physical and chemical composition in a reactor.	Automatic system of technological process control. The second *independent* electronic system.
3.2	Cyclic (circular) muscle layer.	Internal muscle layer of digestive tract. Consists of circular muscles, has four short areas with thick circular muscles -*Sphincters.*	Due to coordinated contraction of circular and longitudinal muscles (wavy peristalsis movement) food lump is reduced to fragments and pushed along the esophagus	Automatically grinds and mixes the content of elastic container and pushes it along elastic pipeline.	*Automatic pipe line transport system consisting of five reactors -accumulators connected by locks.
3.3	Longi-Tudinal Muscle layer	Outside muscle layer of digestive tvact. Consists of longitudinal muscles.	Weakening and contraction of sphincters control the movement of food lump from one esophagus section to another (blockade,* evacuation and separation).	Automatically accumulates definite quantity of elastic containers and transfers one portion through the gate (medium separator) to another reactor.	*
3.4	Auerbach Plexus	Plexus nervosus between circular and longitudinal muscle layers.	Flock of nervous cells of vegetative nervous system, regulating peristalsis.	Controls the process of cutting to fragments and missing the elastic container contents and its transference along the elastic pipeline	Third independent electronic system
4.	Serous shell	Loose, fibrous connective tissue containing nerves, blood and lymphatic vessels coming to and from digestive tract.	The base for holding and attachment of digestive tract to posterior wall of the body, and nerves, blood and lymphatic vessels coming to and from esophagus.The outside surface is wetted to reduce friction of various esophagus sections among themselves and other organs.	Spreader system to suspend the object to girder and simultaneously elastic frame for control of system fastening, input and output information and energy canals.	Outside shell layer. Suspended independent system. The fourth remote electronic system.
5.	Food lump	Food -mixture of carbohydrates, fats, protein, mineral salts, cellular tissue, vitamins, water, admixtures and microelements.	Supply of organism with energy and building material.	Organic fuel and components of building material.	Source of energy and building material placed in elastic container.

— the power layer the reinforcing materials are cloth, net, non-woven fabric, cord, mono-threads and modifications of films;

— the protective layer — encapsulating layer (coating);

— the adhesive layer — the so called adhesion promoters layer to increase the adhesion of the coating and reinforcing material.

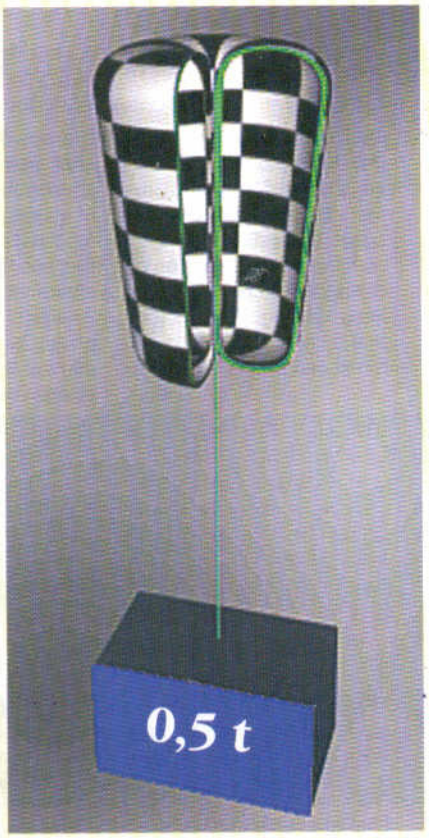
The reference model of such material is an idealized, absolutely impermeable, strong, non-stretchable, flexible, thin and weightless construction material, that has not a counterpart on Earth. The real elastic material must possess estimated strength, impermeability and adequate elasticity and softness. Depending on its application, the material can be single-layer or multi-layer (composite).

Textile, as well as reinforcing layers of composite material are supplied by light industry and can be flat, volumetric, complex (tubular, cellular, spatial etc.). Whatever the case, the fabric is the base for the installment of electronic devices, containing power and information canals in the form of niches and intrusions in the inter-thread area as well as the base for fastening nods and interlocks in the structure of the reinforcing material respectively.

The chips can be also placed in the coating and polymer interlayer.

The size, weight, electrical and other characteristics of the embedded electronic components should not distort the shell's operation inside the elastic machine or mechanism.

Having studied the construction materials used in radio-electronics and



chemistry, and the ideal building material as in the example of the digestive tract of a man and comparing them with the features of kinetically active toroidal elastic shells filled with the fluid (working) medium, we can obtain ideal construction material for elastic machines/mechanisms and an ideal elastic mechanism itself.

Such materials do not exist now. However, the existing simple elements of elastic mechanics, such as shell constructions allow the use of the fluid (working) medium, shell materials and elements of traditional mechanics (levers, hauls, etc.) for achieving the no-step control, the conversion of energy in a continuous working medium and the shell elasticity for mechanical work.

Moreover, today the advanced chemical, radio-electronic and light industry level allow to create such materials.

The creation of new mechanics, namely, elastic engineering is possible only due to the synthesis of many fields of science. All the sciences, which arose out of philosophy and then developed independently, can pool their efforts in creating the elastic machines and mechanisms of the future. Probably, elastic engineering will become the philosophy of our new Millennium.

Working models

transport vehicles of high crosscountry ability;
Heavy-load transport vehicle;
Pipeline transport;
Gravitational container;
Lifting and pulling devices (portable and movable lifts, jacks, towers, winches)-
Hollow-former; Mast lifting device;
Movable support of a pipe length; - Profile-former;
Container;
Load-grasping device, the introduction of handler robot
Mountable-dismountable washing device;
Device to deliver cargo to pneumo- supported and other constructions;
Device for fuel feed;
Device for di arge of load from aircraft;
Docking device; Thermos bottle sleeping bag;
Hydropneumo-driving mechanism;
Conveyor; Toy "Corge", imitation, masking;
Various models of piston mechanisms;
Shock-absorbing and damping device;
Reversible impact device;
Transport vehicle "Mukhtar" (the reversing mechanism is inside the shell) etc.
Application - all spheres of - life and activity.