THE EXCEPTIONAL ADVANTAGES OF PRECESSIONAL TRANSMISSIONS IN THE DEVELOPMENT OF *„MOLECULAR TRANSMISSIONS”* NOMINATED WITH THE NOBEL PRIZE - 2016

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1. THE EVOLUTION OF IMAGINATION FROM FANTASY TO REALITY

1.1. The invention of the laser device and the laser technology boom

The most representative example of the evolutionary path from *fantastic imagination* to *real technologies and applications* in the field of engineering can be considered „*The hyperboloid of the engineer Garin*” from the science fiction novel of the same name by Aleksei Tolstoy. The protagonist of the book, the engineer Garin, obsessed with the desire to become „*the master of the world*”, invents a super-weapon, called *hyperboloid*. According to the functional principle, this is actually a laser (acronym derived from English from the name *Light Amplification by Stimulated Emission of Radiation*) which cut objects in its way by a concentrated beam.

The evolutionary path of the engineer Garin’s hyperboloid from fantastic imagination, presented in his novel published in 1927, until 1964, when the researchers Ch. Tomas, N. Basov and A. Prohorov were awarded the Nobel Prize for the invention of the laser, took less than four decades.

Starting from that nomination of 1964 and until now, we are witnessing a burst of laser technologies in most various fields of human activity: in metal cutting and surface processing of machinery parts; in medicine and dentistry; in computer sciences and computers; in telecommunications and information printing technology; in the technique of measurement and generation of complex surfaces; in information technologies and encoded communications; in agriculture and biotechnology, etc.

1.2. Design and synthesis of molecular machines, nominated with the Nobel Prize - in 2016 - a new era in machinery science

The latest example as important as that of the invention of the laser is the design of *molecular machines*. The Royal Swedish Academy of Sciences, granted on 5 October 2016 and awarded on 10 December 2016, during a formal ceremony in Stockholm, the Nobel Prize to the researchers PhD Jean-Pierre Sauvage from France (Strasbourg University), PhD J. Fraser Stoddart from the US (Northwestern University) and PhD Bernard L. Feringa from the Netherlands (University of Groningen) (Figure 1) for the papaer „*Design and synthesis of molecular machines”*. This crucial event laid the foundations for a new era in machinery science due to the researches done at the junction of molecular chemistry and precision mechanics domains.

Figure 1. *Nobel Prize laureates in Chemistry – 2016: J.-P. Sauvage (on the left), Sir J. F. Stoddart (in the middle) and B. L. Feringa (on the right) for the paper „Design and synthesis of molecular machines”.*

The high Nobel Committee, when presenting the paper „*Design and synthesis of molecular machines*" stated that: „*(...) today, mechanical transmissions, molecular engines and machines largely remain a toy of human imagination, they could not have real functional applications yet, because they are built very hard, but even more difficult is to make them work*". Following this statement of the Committee a rhetorical question arises: ***What was the Nobel Prize awarded for?!***

1.3. Three fundamental steps to the „*design and synthesis of molecular machines*"

To formulate an adequate response to the rhetorical question to the Nobel Committee, we initially propose (*note Ion Bostan*) to generalize the concept of *machine* (macro-machine). According to the definitions accepted in machinery science, the machine performs a distinct function by converting energy from one form to another and is made up of separate parts linked univocally mechanically, forming kinematic couplings and joints with relative movements between them with varying degrees of mobility.

Transposing the defining characteristics of macro-machines to *molecular machines*, the authors undertook three fundamental steps in order to achieve the design and synthesis of the molecular-scale machine.

First step. In **1983**, ***Jean-Pierre Sauvage*** proposed to link two ring-shaped molecules together to form a chain, giving them mechanical bond freer than in usual covalent bonds (stronger).

Second step. In **1991**, ***Fraser Stoddart*** proposed to create a kinematic couple composed of a molecular axle (shaft), on which a molecular ring rotates and moves axially.

Third step. In **1999**, ***Bernard Feriga*** proposed a molecular motor consisting of a molecular rotor with continuous rotary motion in the same direction.

With these three steps, the authors laid the fundamentals of a new era in machinery science, i.e. in the development of molecular machines and their components - molecular mechanical transmissions, motors and devices with controllable movement when receiving energy from outside.

Based on these considerations, the high Nobel Committee, within the meeting of introduction of the paper, also noted: „*(...) the authors nominated, by the three steps suggested for the first time, actually founded the fundamentals of design and synthesis of molecular machines, which in the future will revolutionize various areas of human activity, especially in information technology and medicine*". Through the three steps suggested by the Nobel Prize nominees, they opened the way to making molecular machines work. All the other pertain to the future. It is possible that the future of molecular machines and their components, mechanical transmissions, molecular motors and devices will be linked to the synthesis and development of new concepts of supercomputers, new materials, sensors and over-concentrated energy storage systems.

Making analogy with laser technology boom, triggered by the awarding in 1964 of the Nobel Prize for the laser device, surely a boom in the design and synthesis of molecular machines and their application will follow after 2016 in the case of nano-machines as well.

In fact, the process has already begun. Thus, after the **third step** proposed by Bernard Feringa in 1999, the *molecular motor* has been developed by Christian Ioachim, a visiting professor at A*STAR's Institute of Materials Research and Engineering in Singapore, who, in 2009, was the first in the world who realized how to communicate controllable rotary movement of a wheel of a molecular mechanical transmission having a diameter of d = 1.2 nm (Figure 2) [1].

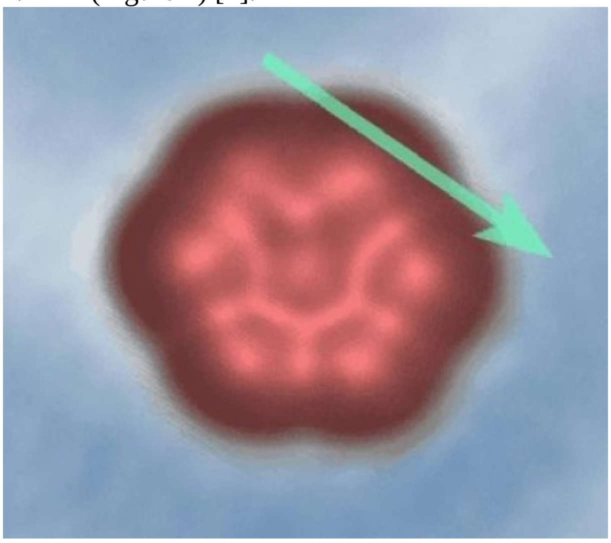


Figure 2. *The first molecular transmission in the world, made to rotate in a controlled manner, published in the journal „Nature Materials" on June 14, 2009.*

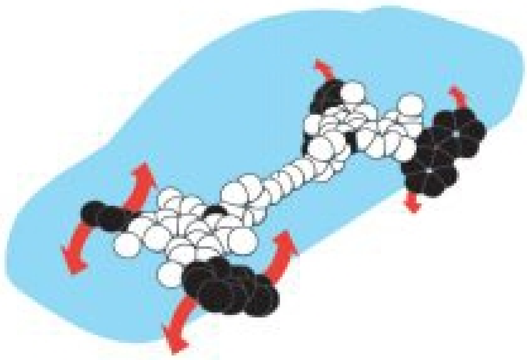
Regarding the importance of the work „*Design and synthesis of molecular machines*", the British periodical „*The Guardian*" writes: „*The three have made revolutionary discoveries in the field of molecular machines - have created nano scale structures with controllable movements by which chemical energy can be converted to mechanical forces. They are molecular machines with controllable movements that can perform certain tasks when receiving energy so that they can be* *used with great benefits especially in IT and Healthcare"*.

So these researchers have managed to revolutionize the synthesis of machinery at the molecular level, thus made it possible to expand the size range of machines from the existing macro-machines with a diameter of their bearings of 8 meters to nano-machines a million times smaller than a millimeter, that is a thousand times smaller than the diameter of a strand of hair.

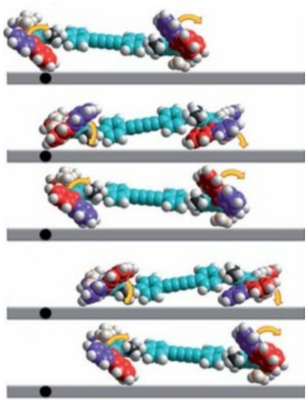
Prospects of development of molecular machines are huge, the areas of applications are incredible, and we expect results that are fantastic - in these terms the Nobel Committee praised the work „*Design and synthesis of molecular machines*" during the meeting of awarding the Nobel Prize.

This achievement of the authors is considered a brilliant debut of *a new era in machinery science at molecular scale*.

The scientists, Nobel Prize winners for the „*Design and synthesis of molecular machines*", consider that applications of *molecular machines* will revolutionize medicine, for instance, by: transportation by molecular vehicles (Figure 3) of medicine directly to cancer cells; performing surgical interventions with the application of molecular robots; using molecular robots and devices to penetrate inside human cells and carry out „*some repairs*" without affecting them; development of new methods of drug administration; replacing the contents of medicinal substances etc.



a.



b.

Figure 3. *Molecular vehicle (a) with molecular drive mechanism (b).*

Also, based on transmissions, molecular motors and devices there will be developed new concepts of computers and communication technologies, and based on molecular machines with some functions it will be possible to replace the current „*stochastic chemistry*" with „*algorithmic chemistry*".

The authors also warn that the molecular mechanical transmissions with high conversion ratios of the movement in large loads and frequency of up to tens of thousands of revolutions per second can concentrate super-huge energy (P, $N{\cdot}m{\cdot}s^{-1}$; T, $N{\cdot}m$; ω, s^{-1}]), which can be used for weapons of mass destruction. According to the predictions made by the authors, these weapons could be made over 20-30 years if no banning sanctions are applied.

1.4. Evolution, similarities and consequences of the two innovations awarded with the Nobel Prize

The two great inventions have undergone the same evolutionary path. In the case of the laser, the transposition period of the *fantastic imagination into reality* started with „*Hyperboloid* ..." published in 1927 (in fact, being based on the operation principles stated in 1916 by Albert Einstein and Max Planck's radiation law, but forgotten until after the Second World War) and ended with the awarding of the Nobel Prize in 1964 for the laser device.

In the case of molecular machines, the first scientific papers appeared in the early '80s, which were cataloged by machinery science scientists of the time as „*phantasmagorical imagination*" and the year 1983 can be considered the start of the research for the transposition of fantastic into reality. The process lasted until 2016, when the work „*Design and synthesis of molecular machines*" was nominated for the Nobel Prize.

It is significant and at the same time surprising that both inventions - the *laser*, and the *molecular machines* - started from fantastic imaginations, the first one in 1927 and the second one in 1983, needing virtually the same period of 34-37 years to develop to become inventions nominated with the most prestigious award for science in the world - the Nobel Prize.

Laser technologies consequences on technical and scientific progress, impacting virtually all areas of human activity, today, over 52 years after the awarding of the Nobel Prize, are known and can be considered revolutionary.

The effects of the second invention, of molecular machines, on human activities are still not known today. But, continuing the parallel analogy with laser technologies and taking into account the conclusions of authors nominated, including of the Nobel Committee, we predict that in the next 40-50 years, there will be developed breakthrough technologies in the field of molecular machines too.

The development of molecular mechanical transmissions and molecular motors represents the result of research at the junction of molecular chemistry and fine mechanics. By the spectacular combination of achievements based on fundamental research in molecular chemistry and the applied ones in precision mechanics obtained so far, it was laid the foundation of a new scientific-practical direction of design, synthesis and revolutionary applications of molecular machines.

2. THE DEVELOPMENT OF MOLECULAR TRANSMISSIONS WORLDWIDE

According to the statements of the high Nobel Committee the merit of the three winners of the Nobel Prize lies in the innovations proposed in 1983 by J. P. Sauvage, in 1991 by F. Stoddart, and in 1999 by B. Feringa, considering them as an integral contribution made in three consecutive steps by which the basic foundations of development of *molecular machines* were laid. The Nobel Committee also noted another important issue, namely that applications of molecular machines are related completely to the future. Thus, it confirms the revolutionary importance of the field and also addresses an appeal and a call to researchers to involve in the development of molecular machines, so that in the future they are used in various fields of human activity.

A series of works were devoted to the area of development of molecular transmissions, and authors of the monograph [2, p. 636] „*The anthology of inventions*", Bostan I. et al. – also referred to some of them: Kinematic planetary precessional transmissions; Molecular mini - and nano precessional transmissions, paper published in 2011 in Chisinau.

Not to leave room for incorrect interpretation from readers, we will present information regarding the „*molecular precessional transmissions developed at the Technical University of Moldova, expressed in the The anthology of inventions*" [2], without introducing any additional amendments or interpretations than those made five years ago.

2.1. Simulated models of nano transmissions ([2, pp. 34-36])

Downsizing mechanical transmissions and electric motors to micron size seems to be the extent possible. What kind of transmissions can be developed with nano scale? What new principles will be developed to build them? Vincenzo Balzani, Margherita Venturi and Alberto Credi, authors of the article [3], come with a provocative idea to go back to Leonardo da Vinci's transmissions to molecular transmissions (Figure 4). The idea consists in forming some "gears" from an agglomeration of molecules, arranging them in a manner established.

Figure 4. *From Da Vinci's mechanical transmissions to nano molecular transmissions.*

In Figure 5 it is presented the model of a molecular transmission with „*toothed belt*", and in

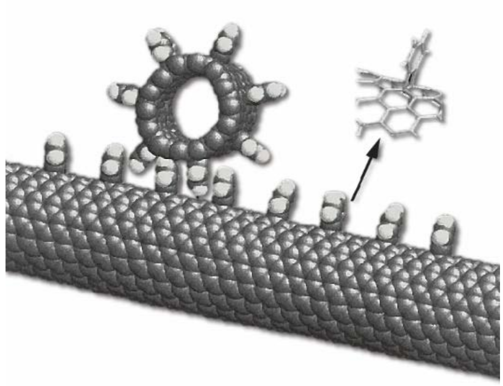


Figure 5. *Molecular nano transmission with belt [4]*

Figure 6 - the model of an ordinary molecular transmission with two „*spur gears*", developed by British researchers Jie Hany, Al Globus, Richard Jaffe and Lenn Deardorff [4].

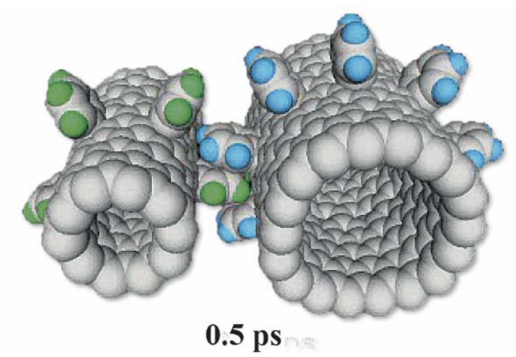


Figure 6. *Ordinary molecular nano transmission [4].*

In Figure 7 [5] it is presented a polymer helicoidal dendronized structure suitable for the formation of a helicoidal nano transmission capable of moving objects with a mass of 250 times greater than its mass.

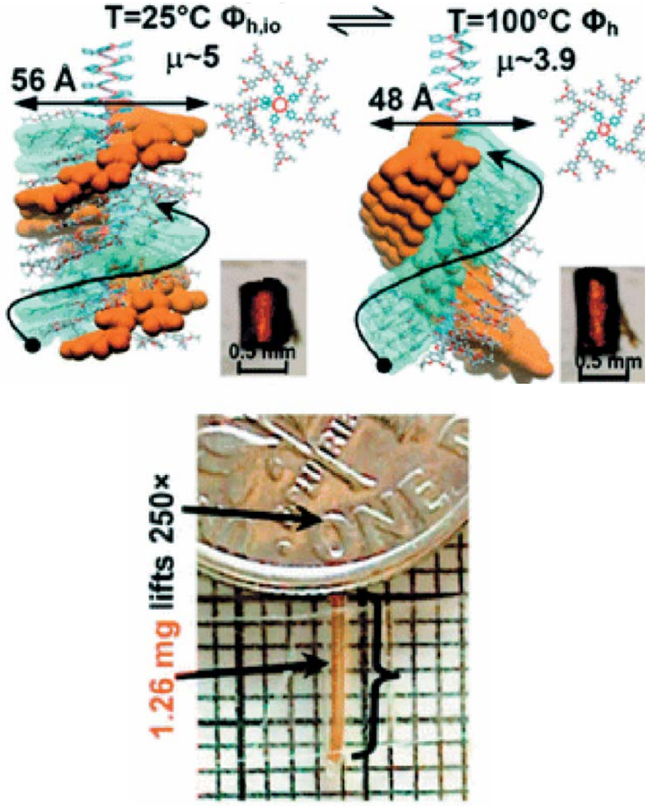


Figure 7. *Dendronized structure to make the molecular helicoidal gear [5].*

Several molecular transmission models developed by the American researcher K. Eric Drexler at IMM (*Institute for Molecular Manufacturing*) [6] are of special interest. In Figure 8 *a*, *b* there are modeled two molecular transmissions with "spur gears" in one step (*a*) and two steps (*b*). In Figure 8 *c*, *d* a planetary transmission with 9 *satellites, solar and central wheel* is modeled, consisting of agglomerations of atoms arranged in a certain way. In figure 9 *e*, *f* a differential is modeled in the *NanoEngineer* software by the researchers K. Eric Drexler and Ralph Merkle at Georgia Tech. University, the USA.

3. MODELS OF MOLECULAR PRECESSIONAL NANO TRANSMISSIONS AND NANO GEAR MOTORS *2K-H* ([2, p. 72-76])

The previsions of scientists [3-7] in the fields of nanotechnology and macromolecular chemistry on the creation, based on special techniques, of various mechanisms and functional machines at the molecular scale open new opportunities for collaboration of specialists at the junction of mechanical and nanotechnology fields. Thus, in the specialized literature information was published about the achievements of Italian researchers [3] regarding the tests on prototyping the mechanical transmission of Leonardo da Vinci at the molecular level, of the transmissions through the toothed belt and cylindrical wheels prototyped by British scientists [4], of planetary transmissions with satellites, and of differentials by the American ones [5, 6]. In all scientific sources it is mentioned the collaboration of researchers from at least two areas - nanotechnology and mechanics. Due to the unique constructive kinematic particularities of the precessional transmissions, related to the sphero-spatial movement of the satellite, by which very large movement converting ratios are ensured, they, according to the authors, are of particular interest in terms of their prototyping at molecular level.

3.1. Molecular precessional nano-transmission 2K-H ([2, p. 73-74])

The constructive specifics of precessional transmissions ensures the construction of all structural elements (of the satellite, central gears, shaft and housing), for example, from multi-walls concentric carbon nanotubes by synthesizing technologies newly available to the engineering practice. In Figure 9, the authors show the construction of the molecular precessional nano transmission of *2K-H* type, made up of satellite *1*, with two crowns *2* and *3* consisting of atoms, the peripheral fields of interaction of which form

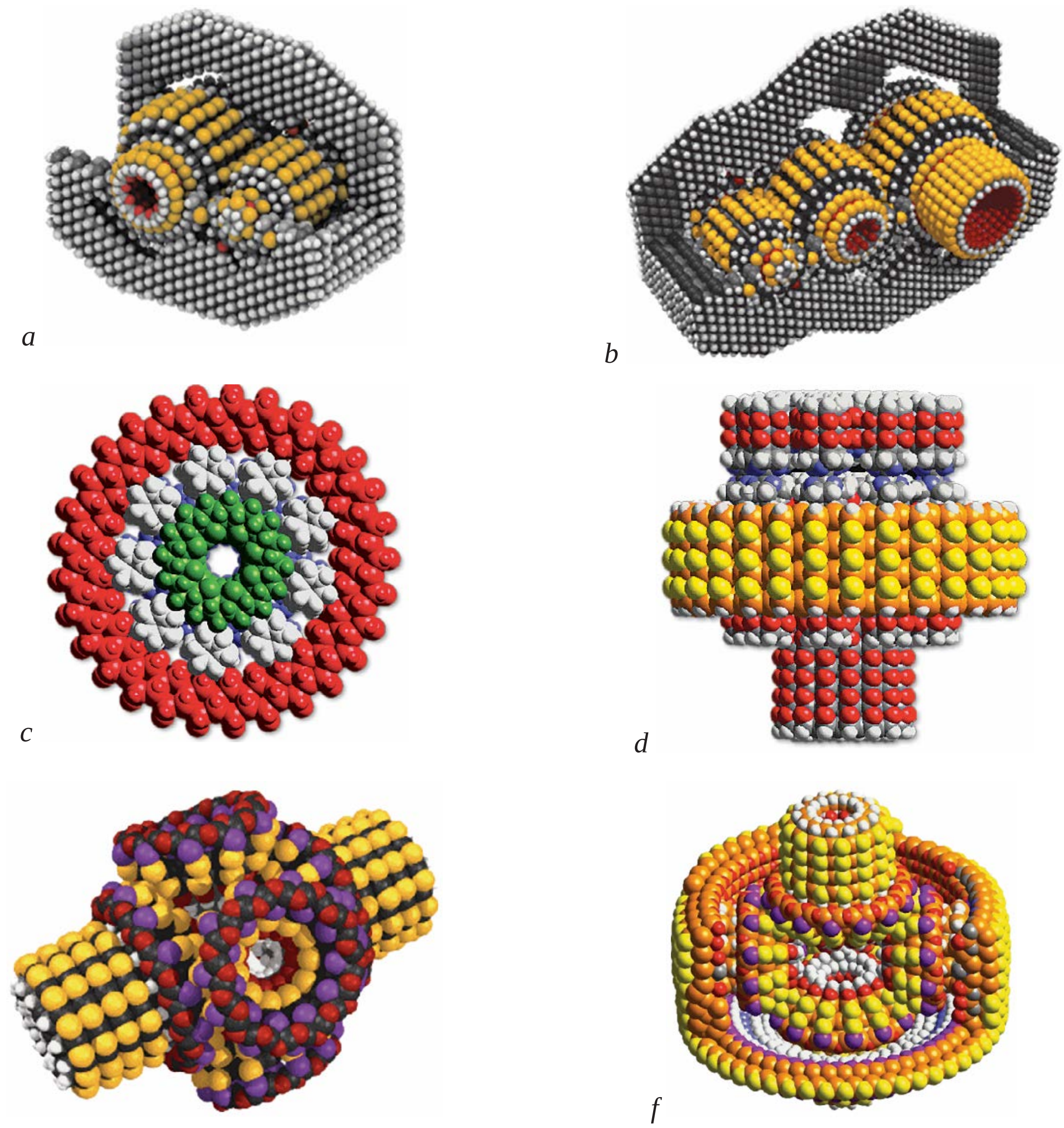


Figure 8. *Molecular nano-transmissions: transmission with spur gears in one step (a); transmission with spur gears in two steps (b); planetary transmission with nine satellites (c, d); differential (e, f).*

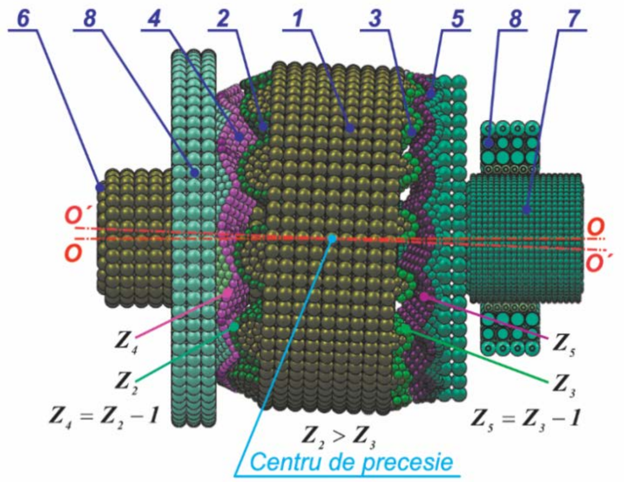


Figure 9. *Molecular precessional nano-transmission 2K-H.*

envelopping surfaces with the profile in circular arc, similar geometrically with those of the crowns of the satellite from the regular precessional transmission. The teeth of the central wheels *4* and *5* are made up of atoms placed into space so that the enveloping of fields of atomic interaction to form imaginary convex-concave surfaces congruent with teeth profile in the regular precessional transmission. The number of teeth with imaginary surfaces described in the circular arc that form the teeth *2* and *3* of the satellite must be $Z_2 = Z_3 + 1, 2, 3, 4...$, and of the teeth of the central wheels which form the conjugated teeth with convex-concav profile - $Z_4 = Z_2 \pm 1$ şi $Z_5 = Z_3 \pm 1$.

The operation principle of the nano transmission is similar to the one of the regular precessional transmission. When rotating the input shaft *6*, the satellite *1* will perform sphero-spatial movement around the center of the precession *O* and its crowns, with numbers of teeth Z_2 and Z_3, will interact with the teeth of central wheels Z_4 and Z_5. If the central wheel *4* is immobilized, the gear ratio at shaft *7* will be:

$$i = \frac{Z_2 Z_5}{Z_3 Z_4 - Z_2 Z_5} \quad (1)$$

Depending on the number of teeth Z_2, Z_3, Z_4 and Z_5 and their correlation the movement reduction can be from ±*10* up to *3600* in a single step.

Examples of creating molecular multistage transmissions, shown in Figure 8 *b* [6], and the of planetary ones in Figure 8 *c*, *d*, show that transmission ratio can be of importance. In this regard, we note that an eventual precessional transmission built according to the complex kinematic structure *2K-H* (see kinematic structure, [8] Figure 12) can have a reduction ratio of the rotational movement of over *10 000 000* in a construction with only two satellites. According to the source [5], a molecular helicoidal transmission is capable of moving objects with masses 250 times greater than its own mass, capacity dependent on the the reduction ratio of the rotary movement (i = *250*). In this context we mention that the reduction ratio of the revolutions in the molecular precessional transmission can be of tens of millions.

According to the projections made in [3-7], the authors consider that molecular precessional transmissions (TP) will be of particular interest for the following reasons:

– possess exceptional possibilities for reducing the rotary movement;

– sphero-spatial movement of the satellite is similar to the movement of the atoms' thorn;

– possess constructional simplicity using only four structural elements which can be built, for example, from carbon nanotubes.

Using the principle of movement converting and of the load in TP with sphero-spatial movement with a fixed point of the satellite and constructive-kinematic peculiarities thereof, the constructive structure of a precessional nano gearmotor is proposed in [2].

3.2. Molecular precessional nano gearmotor ([2, p.74-76])

We admit that based on special technologies mentioned in [3-7] we build a satellite with two crowns of teeth, with the geometry of the gears similar to that in the transmission shown in Figure 9. By the technologies referred to, we fix to the satellite body *1* (Figure 10) ionized atoms in the the

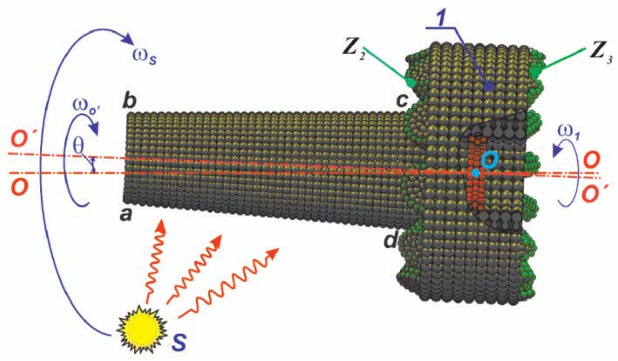


Figure 10. *Kinematics of the satellite of the precessional nano gearmotor.*

trunk space of the cone *abcd*, responsive to the external action, for example, of a rotary electrostatic field, of an electromagnetic field or radiation etc. The action of the rotary external energy source on ionized atoms with angular velocity $\omega_0 = \omega_s$ involves the sphero-spatial moving satellite rotating it around its axis *O'O'* with angular velocity:

$$\omega_1 = \frac{\omega_s}{i} \quad (2)$$

where: $i = \dfrac{Z_2}{Z_4 - Z_2}$

If $Z_4 = Z_2 - 1$, then $\omega_1 = \frac{\omega_S}{Z_2}$, and if $Z_4 = Z_2 + 1$, then $\omega_1 = -\frac{\omega_S}{Z_2}$.

On the whole, the reduction of the angular velocity on the output shaft *7* of the transmission is given by:

$$\omega_1 = \frac{\omega_s (Z_3 Z_4 - Z_2 Z_5)}{Z_2 Z_5} \quad (3)$$

where $Z_4 = Z_2 - 1$, $Z_5 = Z_3 - 1$, $Z_2 > Z_5$.

In figure 11 the precessional nano gearmotor *2K-H* is presented, with the operating principle based on the communication of part *6* of a diurnal rotary movement with the nutation angle θ, and to the satellite *1* - sphero-spatial movement with a fixed point. The nutation angle θ of the sphero-spatial movement of the satellite *1* can vary $1^o < \theta < (15 \div 20^o)$ and is selected based on the same geometric parameters (δ, β, θ, Z_4, (Z_5), $Z_{2(3)} = Z_{4(5)} \pm 1$) of regular precessional gear units. So, the kinematic-constructive peculiarities and the specific principle of movement converting in the TP ensure

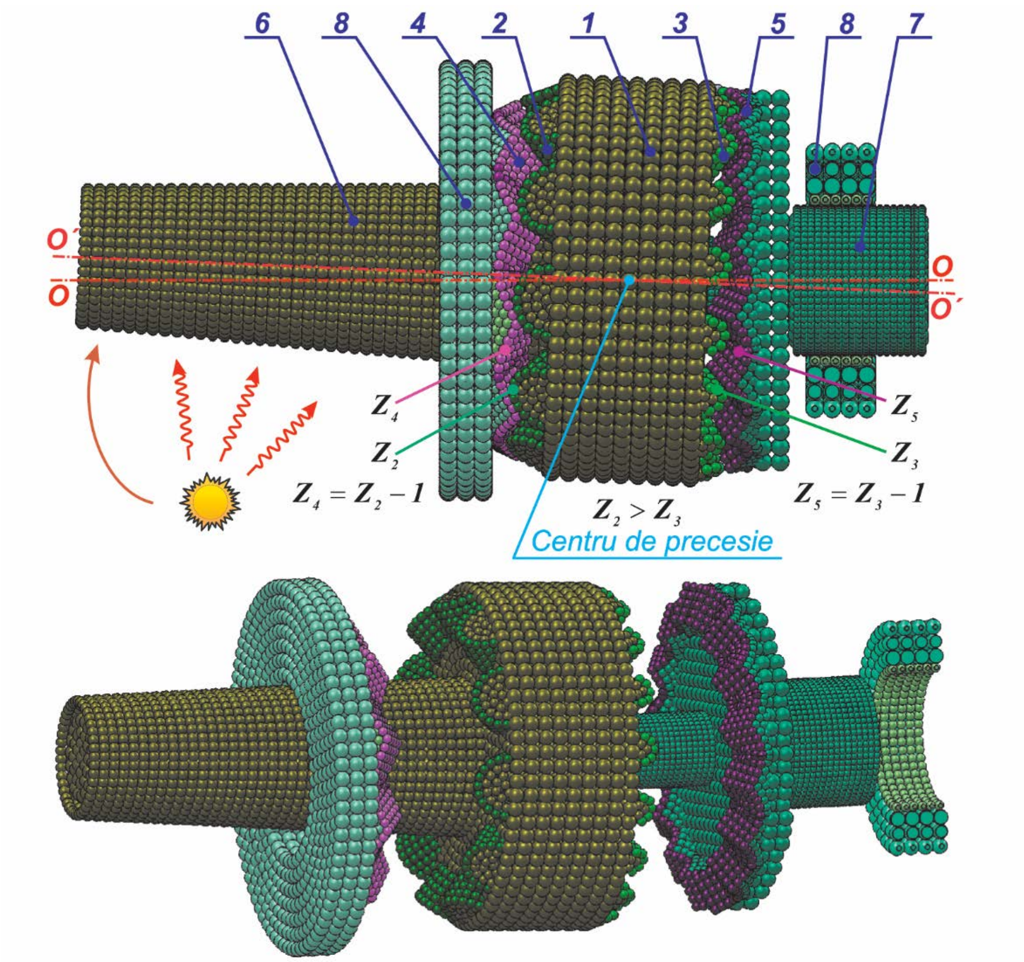


Figure 11. *Precessional nano gearmotor 2K-H (a) and in the deployed variant (b).*

merging motor and reducer functions in one construction - precessional nano gearmotor.

The authors consider that based on precessional planetary transmissions can be constructed nano transmissions in a range of over 20 structural schemes developed.

According to the projections of specialists, molecular nano transmissions and nano gearmotors will find electronic, optical, magnetic, mechanical applications in various engineering nanosystems with properties and effects still hard to imagine today.

Five years after the publication in 2011 of „*The anthology of inventions*” [2] on the development of molecular technologies we can make a few observations:

1. A particular interest is attested worldwide regarding the development of molecular machines and their components - molecular transmissions and motors in terms of their computer modeling and synthesis.

2. Despite the finding in p.1, the synthesis of molecular machines worldwide so far is carried out by primitive molecular technologies of permutation of only large conglomerates of atoms in their infinitesimal “submission” to permutations and that is why a stable molecular balance is not ensured (because of the instability of atoms permutated).

3. Until now scientists and engineers have not yet developed concepts of „*assemblers*” or „*disassemblers*” of the atoms in the molecules, which in future will be the most important molecular instrumentation used in the synthesis (building) of molecular machines by permutation of atoms according to the principle „*one by one*” (and, respectively, the disassembling of molecular machines by removing atoms „*one by one*”). The operation of molecular assemblers will be conducted by molecular computers [7].

4. The awarding of the Nobel Prize in 2016 for the „*Design and synthesis of molecular machines*” will certainly boost research in the field of molecular machinery science. This will lead to shorter time in the development and manufacture of molecular assemblers through molecular technologies conducted by molecular computers. Thus, there will be laid the fundations of the Molecular Industry.

4. EXCEPTIONAL ADVANTAGES OF PRECESSIONAL TRANSMISSIONS (TP) FOR THE DEVELOPMENT OF MOLECULAR MOTORS AND TRANSMISSIONS

Molecular nano-transmissions with cylindrical wheels in one step (Figure 8a) and in two steps (Figure 8b) are favored by constructive simplicity, they ensure working regime both in the reduction and multiplication of movement and possess gear ratios, consecutively $i = 2 \div 8$ and $i = 8 \div 50$. Planetary transmissions with 9 satellites (Figure 8 c, d) provide higher gear ratios $i = 10 \div 250$ and high load bearing capacity determined by 9 satellites, and the differential (Figure 8 e, f) has possibilities of differentiated reduction of the input shaft rotation.

The major drawback of these transmissions is that to make them work you must interlock them to a separate molecular motor or to make at least one wheel (or shaft) rotate.

The advantages of precessional transmissions favorable for the design and synthesis of molecular motors and transmissions are described in „*The anthology of inventions*" [2, p.73-74].

1. The most important advantage is the movement converting specifics and of the load used in TP, namely of the sphero-spatial movement of the satellite with a fixed point. This specificity of TP facilitates synthesis of molecular precessional motors based on a principle other than the one proposed in 1999 by the Nobel laureate - 2016 Bernard Feringa (identified by the winners as *step three* of the innovations), or than that achieved in 2009 by Christian Joachim - considered the first in the world who has managed to spin a molecular wheel.

The principle proposed to make molecular precessional transmissions work as a molecular motor was first described in „*The anthology of inventions"* [2, p. 74-76], and consists of the involvement of the precessional satellite in a sphero-spatial movement with a fixed point by exposing the satellite to an external rotative source of light (or some fields: electrostatic, electromagnetic, radiation) with a certain frequency of rotation. The asymmetric forces in the vectorial lateral precessional gears compensate themselves and, under the action of external energy (of the rotative light), communicate to the satellite quasi-mechanical precessional movement with a nutation angle θ (see Figure 10) determined by the geometry of the gearing formed by groups of atoms. In turn, the satellite in its precessional movement (caused by external energy source) transmits to the central mobile wheel rotary movement with reduction according to the mechanism existing in precessional macro-transmissions.

2. Another advantage of the precessional transmissions, which facilitates the synthesis of molecular precessional transmissions, consits in the lateral location of the precessional gears so that the profile of the envelopping of the field of atom groups forming the teeth of the satellite describes the arcs of circles, and the envelopping of the central wheel teeth to describe the convex-concave curves (figures 9-11) congruent with teeth profiles in precessional macro-transmissions. Such location of atom groups ensures their multiparous gearing, and the sphero-spatial movement with a fixed point of the satellite and the difference of atom groups of ± 1 ensure the reduction in rotational movement with a ratio in the range $i_{HV}^{B} = \pm 10 \div 3600$ in simple kinematic structures with just four constituent parts prototyped based on the precessional transmission *2K-H* (Figure 12, j).

The synthesis of molecular precessional transmissions on the basis of kinematic structures shown in Figure 12, *k-o* ensures a wide variety of locations of groups of atoms with their envelopping in the form of convex-concave profile, which would satisfy certain demands of researches - designers of molecular precessional transmissions with transmissions ratios $i_{HV}^{B} = \pm 10 \div 3600$. In all molecular precessional transmissions synthesized according to the kinematic structures shown in Figure 7, the denture of the teeth or of the satellites with bolts are replaced continuously in the shape of circle arc because in the molecular precessional gears friction forces are missing. Just changing the number of teeth in the groups of atoms we can substantially change the gear ratio in the same constructive configuration, including the direction of the rotational controllable movement.

3. Precessional transmissions developed in the '80s [8] compared to other classical transmissions possess a much more extensive variety of functional capabilities and kinematic structures shown in Figure 12. Each of the kinematic structures shown in Figure 12 taken as the basis for the design and synthesis of molecular precessional transmissions or molecular precessional motors can respond to various requests from researchers-designers of molecular machines. For example, the kinematic structures K-H-V shown in Figure 12 a-e, g are made of a precessional geared satellite with a central wheel and additionally with a mechanism for receiving and transmitting a rotary controllable movement. These transmissions are working in both

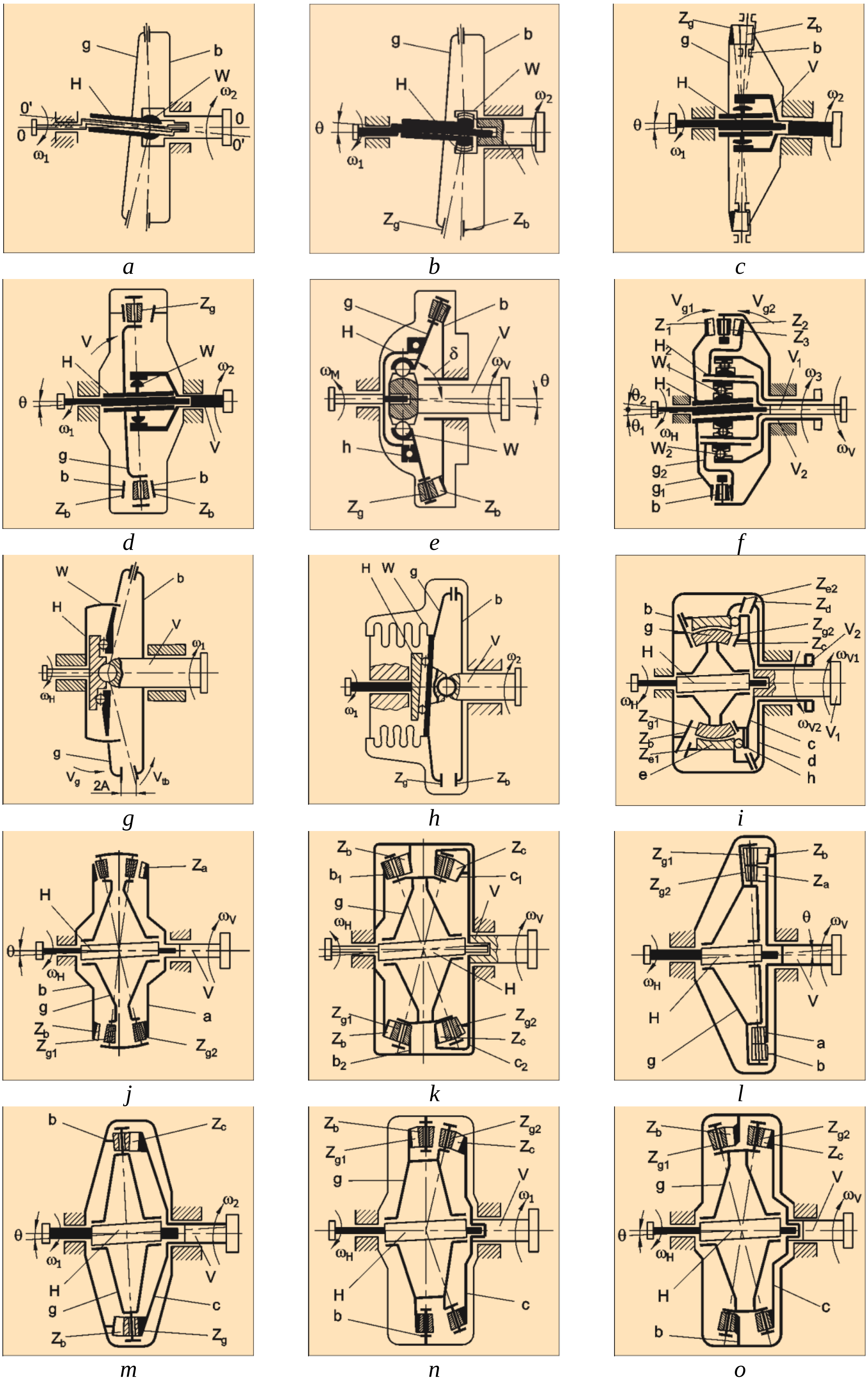


***Figure 12**. Kinematic structures of precessional transmissions:*
K-H-V with immobile central wheel (a-f), K-H-V with mobile central wheel (g, h), complexes (i) and 2K-H (j-o) (a, c – mobile central wheel, b – fixed central wheel, g – satellite, H – precession generator, V – output shaft, W – mechanism for receiving and transmitting a rotary movement, Z – the number of teeth).

reduction and multiplication regimes of the rotary movement, with the reduction (multiplication) ratio $Z_b = Z_g + 1$, $i_{HV}^b = -Z_g$, when $Z_b = Z_g + 1$, $i_{HV}^b = -Z_g$, but when $Z_b = Z_g - 1$, $i_{HV}^b = Z_g$ where Z_b, Z_g - the number of groups of atoms/molecules which constitute the teeth of the central wheel andof the satellite of molecular precessional transmission. Reduction (multiplication) ratios of the rotation movement in the precessional transmission K-H-V vary between $8 < i_{HV}^b < 50$. The kinematic structure shown in Figure 12, f can be used to develop the molecular vehicle to transport drugs to the cancerous cells providing the separation of vacuumed hermetic spaces not to affect healthy cells, and the structure shown in Figure 12, i ensures design and synthesis of molecular precessional transmissions with a rotational movement ω_H at theinput and two rotational movements with $(\pm)\omega_V$ and ω_3 at the output.

4. Another outstanding advantage of precessional transmissions made through the kinematic structure, Figure 12, i, and not found in other classic transmissions lies in the possibility to achieve very large transmission ratios (up to tens of millions) and, accordingly, torques (M_{v2}) of tens of millions of times greater at the output than at the input in the molecular precessional transmission (M_1). Also, in the molecular TP, the input angular velocity ω_1 can be thousands of revolutions per second. Thus, in the molecular precessional transmission we can develop tremendous forces in quasi-mechanical movements (torques) or can focus over-energies equivalent to $P = M_{v2}\omega_2$ at the output of the molecular precessional transmission.

5. A general and very important advantage lies in merging the functions of molecular transmission and molecular motor in one structure with communication of one nutation movement with the angle θ to the precessional satellite.

CONCLUSIONS

The process of developing molecular motors is now in the same state as the electric motor was in 1830 when researchers of time were creating various devices, levers, shafts and wheels without being aware that their primitive inventions were to result in electric trains, washing machines, to building factories producing metalworking machinery making themselves other machines etc.

In the case of molecular motors and transmissions time will come when on their basis molecular robots will be built for factories producing new products on a molecular scale, and new nanomaterials, energy storage nanosystems, molecular nano chips for new generations of computers, nano vehicles for the transportation of drugs to the cancerous cells, nano robots to penetrate inside human cells to perform any surgical repair without affecting them etc.

These machines, robots and vehicles with molecular motors will produce quasi mechanical controllable movements for the realization of certain useful functions, consuming no traditional „*fuel*” but chemical energy (light, electrostatic, electromagnetic fields or radiation) converted into mechanical energy.

At present the main obstacle in the boom of molecular technologies is still the inability of researchers and engineers to design and fabricate molecular „*assemblers*” which the development of Molecular Industry in the world depends upon.

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Recommended for publication: 20.09.2017