Institute for Information Transmission Problems

LABORATORY 8

Laboratory of Sensory Information Processing

Executive Head of Laboratory – Dr. (Biology) Vladimir Bastakov
Tel.: (095) 200-14-77, Fax: (095) 209-05-79; E-mail: bastakov@iitp.ru

The leading researchers of the laboratory include:

Dr.Sc. (Biol.)	D. Lapshin	Dr.	V. Maximov
Dr.Sc. (Techn.)	D. S. Lebedev	Dr.	O. Orlov
Dr.Sc. (Math.)	D. G. Lebedev	Dr.	T. Podugolnikova
Dr.Sc. (Biol.)	I. Pigarev	Dr.	E. Rodionova
Dr.Sc. (Biol.)	G. Rozhkova	Dr.	M. Smirnov
Dr.	K. Golubtsov	Dr.	V. Vedenina
Dr.	E. Maksimova		P. Maximov

FIELD OF RESEARCH

The main research area of the laboratory is investigation of information processing in sensory systems and in nervous system of man and animals in general. These researches are aimed onto:

- elaboration of adequate models which show how the studied principles of information processing in the nervous system are realized in the formation of complex behaviour;
- elaboration of mathematical models simulating significant functions of distinct divisions of sensory systems, including peripheral, central and sensorimotor levels of information processing;
- comparison of principles and solutions of similar problems in live and technical information systems intended to improve the later;
- designing and implementing diagnostic methods and devices for ophthalmology.

To cope with the problems mentioned, different approaches and methods are used by the laboratory researchers, including neurophysiological, psychophysical and morphological methods, as well as animal behaviour field studies and computer simulations of sensory processing. Among the most important problems is description and classification of numerous functional types of neural units which are involved in the sensory information processing at several levels of integral nervous system. Thus, in vision the peripheral level of information processing is represented by the retina, while the brain visual centres (cortex and caudate nucleus in cats and monkeys, diencephalon and mesencephalon in fish and in frogs) represent the central level. Investigation of neurons' functional types is performed by means of both neurophysiological and morphological methods. Microelectrode experiments are aimed on recordings of responses from separate single units (neurons) at different levels of the retina, which itself is composed of several distinct layered nerve structures, each of them being a complex ordered network built of different neuron classes. These experiments are performed on immobilized live animals using their visual stimulation. Morphological studies specify those neural structures and morphology of the nerve cells which are subject of neurophysiological investigation. Functional features of neural components are the matter of comparison to some distinct forms of sensory-guided integral behaviour of the same experimental animals (fish, amphibia cats),

this way providing the background for modeling of corresponding neural circuits in terms of computer simulations. Such, computer simulations include modeling of neural event underlying of information processing at the level of cone receptor population (in primate retina), as well as interaction of receptor and horizontal cells in the retina (in fish). General principles of sensimotor information processing (such as colour and size constancy in visual perception, binocular vision mechanisms, spatial orientation, echolocation in moths, bioacoustics in locusts during the breeding period) are the matter of psychophysical experiments on both healthy subjects and medical patients having different sensory disturbances; as well as in behavioural experiments on animals. Basic researches provide the background for applied outcomes in the form of diagnostic methods and devices for medical ophthalmology, which are as well being designed and implemented by the laboratory staff.

In our "paper colourimetry" experiments with manual or mechanical movement of papers painted in different colours on backgrounds of other colours, directionally selective ganglion cells of the fish retina projecting to the tectum opticum was shown to be practically colour blind, for it was always possible to match stimuli with backgrounds varying only their intensities. Sensitivity of these units was placed in the long-wave end of the spectrum. We are able to refine the situation presenting on colour monitor screen stimuli of high contrast, specified for the visual system of goldfish. The spectral sensitivity of directionally selective units had been found to determine not only by the red-sensitive cones but green-sensitive ones also. Green-sensitive cones participate weekly with opponent manner. So the sensitivity of directional-selective units is reduced in the blue-green end of the spectrum, its maximum shifted even further to the red end. This shift of spectral sensitivity may be considered an adaptation to the underwater condition, where acute vision is possible only in long wavelength because of the substantial light scattering in blue-green region of the spectrum. (V. V. Maximov, E. M. Maximova)

A hypothetical post-retinal mechanism for separating the red-green opponent signals from the outputs of the midget ganglion cells, which are a mixture of red-green and brightness signals, is presented. The mechanism consists of an inverter and a low space frequency filter, which are series connected. The inverter forms two groups of signals: the first one is a set of the outputs of the on-ganglion cells with L-center and off-ganglion cells with M-center; the second group consists of the outputs of the on-ganglion cells with M-center and off-ganglion cells with L-center. The filter suppresses the false color opponent signals caused by stimulus brightness changes. As a rule such filtration provides forming the "pure" color opponent signal. But the computer experiments show that some special stimuli create the false color opponent signals, which are so powerful that the filter cannot completely suppress them. Probably these results explain the origin of the illusory colors caused by some achromatic stimuli in psychophysics experiments. (D. S. Lebedev)

Possible mechanisms of the colour opponency (CO) in the outer retina were considered. A mechanism of the CO by means of Byzov's ephaptic feedback from horizontal cells to cones is investigated in detail by use of computer simulation. Cone output signal – glutamate release – is controlled by potentials of horizontal cells which are synaptically connected with cones. However, unlike feedforward versions, such scheme of the CO meets with some logical difficulties. Physiological functions usually attributed to CO require the opponent signal to be independent of brightness ("pure" CO). For that the transmitter release must not depend on intensity of the stimulus. A paradox is that in this case HCs apparently do not receive any information about the intensity too and so cannot provide necessary feedback. Unfortunately,

the fact, clear to any radio-engineer, was not fully realized by neurophysiologists. The paradox can be settled by assuming that the feedback loop possesses practically "infinite" gain. Then the output cone signal proves to be rather stabilized, while the HC potential does reflect variations of intensity and supply necessary signal for feedback. A substantial amplification of graded potentials in HCs is possible due to voltage-dependent properties of their nonsynaptic membrane. Appropriate "negative" resistance of the HC membrane was described by A. L. Byzov et al. in fish retinas (A. L. Byzov et al. Vision Research. 1977. No. 17. P. 265-273), but its function remained unclear since 1977. The first, analog model made on the basis of operational amplifiers (op amp) confirmed that responses independent of the intensity of input stimuli can be achieved by use of the op amp with "infinite" gain in the feedback loop. The second, detailed computer model of the retinal network in the framework of Byzov's hypothesis of the ephaptic feedback in triade synapses shows that a feedback via HCs possessing membrane with negative slope resistance indeed simulates necessary "pure" CO (V. V. Maximov, P. V. Maximov).

A new explanation for the orientation-contingent colour after-effect also known as the McCollough effect (ME) is proposed. Like other illusions the ME is supposed to be a result of activity of some visual mechanism (presumably, the novelty filter) that is useful in natural conditions but gives wrong visual perception under special experimental stimulation. As to ME there were no clear view on possible role of the novelty filter in the visual system. It is usually considered that this filter stores frequently appeared image in distributed synaptic weights and subtracts it from the current input image. However the novelty filter can be represented as a special device that eliminates cross-correlation between the input signals. In this case it may be used as a tool for correcting of a priori unknown optical distortion (such as defocusing, astigmatism, chromatic aberration and so on). Pilot experiments with a computer model show that the novelty filter can remove the redundancy of input visual information. In particular, this redundancy may appear due to a significant overlapping of spectral sensitivities of red and green cones. In this case after a long adaptation to such correlated signals the novelty filter would perform a colour-opponent transformation (P. V. Maximov, V. V. Maximov).

Until recently, in most studies of binocular vision, the attention was focussed almost exclusively on the mechanisms of stereopsis based on looking for the matched elements in the left and right images and comparing their positions. At the same time, the human binocular system also include principally different mechanisms capable to produce a single binocular percept from unpaired left and right fragments in the absence of corresponding elements. These integrative mechanisms seem to be of particular interest in view of the finding that, in the cases of binocular disorders, they usually become disturbed later and restore earlier than others. Comparative studies of the integrative mechanisms in adults and in children of various ages with normal binocular vision and with binocular anomalies have shown that the rate of binocular integration reachs the adult level at about 9 years of age. The data obtained could be used for differential diagnostics, optimization of treatment and prediction of the expected progression in the course of binocular vision abilitation and training (G. I. Rozhkova, T. A. Podugolnikova).

In our previous study ("Neuroscience", 1993) it was demonstrated that neurons in the primary visual cortex of cats responded to the intraperitoneal electrical stimulation during slow wave sleep. This observation opened the new direction for the investigation of sleep function. However, it was often argued that electrical stimulation was artificial for the visceral organs and the recorded responses were nonspecific in nature.

The goal of our study during this year was to check our observation using only natural activity of the gastro-intestinal system. Three cats were operated for chronic recordings of neuronal activity in the cortical visual area V4A. Electrodes for chronic recording of myoelectrical activity were also implanted into the smooth muscles in the walls of stomach. Electrodes in stomach recorded typical migrating myoelectrical complexes – high amplitude bursts of the periodic activity. This activity take place in a stomach with intervals 10 – 20 seconds and reflect strong muscle constructions. It was found that during slow wave sleep appearance of these complexes coincided in time with strong increase of neuronal firing in cortical area V4A. Eye movements, which can be recorded during slow wave sleep also demonstrated correlation with stomach activity. These observations confirmed the involvement of cortical areas in the processing of visceral information during seep and have directly demonstrated that slow wave cortical activity during sleep reflect activity of the gastro-intestinal system (I. N. Pigarev).

In prey–catching behavior of monocular frog under experimental control during slow approach to stable prey, for the first time the features of the visual stimulus (namely, its lateral shift without distance change, and the change of its visible angular size), have been revealed, the change of which lead to illusion of distance change between animal and stimulus, although this distance did not change indeed. In psychophysical experiments on human subjects likewise situation had been tested. In the case when one eye had been occluded, subjects perceived distinct illusion of lateral (outward of visual field) stimulus displacement when the stimulus approached, and an opposite (inward) if the stimulus moved away (V. A. Bastakov).

Two points of interrelation between vision and language are discussed, (i) one regarding resemblance of processing of these two so much unlike sensory flows, and (ii) the second, abundance of words and lexemes describing thinking and mental events in the "cognitive" area, and such concerning communication and interpersonal contacts, which appeal to associations from visual experience. "Vision-related" words and idioms belonging to these topics may be of interest for comparative–lexicological study in non–relative languages, because they may reveal some conservative mental tendencies common to people in general (O. Yu. Orlov).

We have investigated the effects of peppermint and lavender odors, presented during a class-work, on the students' performance in math and spelling at elementary and middle school. Peppermint presented in the air in a very low concentration (0,03 mg/m^3) significantly improved the students' performance in the word-dictation spelling test. The effect manifested itself as a decrease of the mean number of errors and a respective increase of the mean school-mark. Peppermint, however, did not affect the performance in the text-copying test, which depended more on attention than on memory. A similar selectivity of peppermint towards the math tests was revealed. The performance in the arithmetic dictation was improved by peppermint, but the results in the written math test were not affected. It seems that in both dictation tests the performance depends on a common mental process, that probably employs operative memory, which was facilitated by peppermint. Lavender demonstrated a dual effect: like peppermint, it improved the performance in word dictation but adversely affected the students' performance in both math tests (E. I. Rodionova).

The shape of the threshold-frequency characteristics of the echolocating moths was studied with varying delay of the tonal stimuli in relation to the own signals of the insects. It was shown that the zone of the optimal acoustic reception was moving along the frequency axis in a cyclic manner. Immediately after the emission of the echolocation click, the acoustic system was "tuned" to the main spectral peak of the

expected echo signal (40-50 kHz) but, in 15 mc, the optimal zone was already shifted to 24 kHz. The tuning frequency of the acoustic system was determined by the tension of the tympanal membrane by methatoracic muscles. The particular attention of the insects to the low-frequency part of the ultrasonic range could be accounted for by their need to control the surrounding space in order to detect echolocation signals of the approaching predators (D. N. Lapshin).

In the behavioral experiments, intact females of the two closely related species *Chorthippus albomarginatus* and *C. oschei* selectively (in 80-90% of cases) responded to the intact conspecific males in choosy conditions. Elimination of the chemical or visual components of the complex courtship signal did not change a female selectivity, whereas elimination of the acoustic component decreased both the female selectivity and the whole number of the positive responses. Thus, acoustic component of the courtship is not only a reproductive barrier between closely related species but also a component of sexual selection. A rate of hybridisation between closely related species *C. albomarginatus* and *C. oschei* was evaluated on the base of associations between different characters (acoustic signals and morphological characters). In 15 populations of the hybrid zone, a correlation between courtship songs and the number of stridulatory pegs was revealed for all males studied (V. Yu. Vedenina).

SCIENTIFIC EVENTS

The meeting devoted to the memory of the corresponded member Russian Academy of Sciences A. L. Byzov was held 2002, February 12. The organizers L. M. Chailahjan and V. A. Bastakov.

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 00-04-48657):** "Mechanisms of moving objects size constancy perception in frogs and toads" (V. A. Bastakov).
- **Russian Foundation of Basic Research (No. 01-04-48632):** "Mechanisms and functions of colour opponency in vertebrate vision" (V. V. Maximov).
- **Russian Foundation of Basic Research (No. 00-04-48704):** "Investigation of topographic macromosaic and the properties of constant presentation of depth in fourth extrastriatal layer (visual zone V4A) of occipital cortex of cat" (I. N. Pigarev).
- **Russian Foundation of Basic Research (No. 01-04-49484):** "Mechanisms of age-dependent changes of visual acuity" (G. I. Rozhkova).
- **Russian Foundation of Basic Research (№ 02-04-07552):** "MAC" (P. V. Maximov).
- **Russian Foundation of Basic Research (№ 02-04-48256):** "Frequency tuning of the hearing system of noctuid moths (Lepidoptera, Noctuidae) (D. N. Lapshin).
- **Russian Foundation of Basic Research (№ 02-04-58750):** "Partake in Europe Conference on Visual Perception (ECVP), Glasgo, GB, 2002, 25.08-29.08". (P. V. Maximov).
- **Russian Foundation of Basic Research** "Partake in Europe Conference on Visual Perception (ECVP), Glasgo, GB, 2002, 25.08-29.08". (D. P. Nikolaev).
- **Russian Foundation of Basic Research (№ 02-04-589052): "**Partake in 22nd Workshop of "The J.B. Johnston Club". USA, Orlando, 2002, 30.10-10.11". (V. A. Bastakov).
- **Sense of Smell Institute Grant**: "The effects of fragrances on memory and mental performance in schoolchildren" (E. I. Rodionova).
- **Alexander von Humboldt Foundation Grant (Stipend), IV RUS/1054747 STP:** "Hybrid zone and barriers to gene exchange between closely related grasshopper species of the Chorthippus albomarginatus-group" (V. Yu. Vedenina).

PUBLICATIONS IN 2002

Articles

1. Бызов А.Л. Физиология сетчатки: нейромедиаторы и электрогенез. – В кн.: Клиническая физиология зрения. Ред. А.М. Шамшинова и др. М.: МНИИГБ им. Гельмгольца, 2002. С. 25-37.
2. Воронцов Д.Д., Лапшин Д.Н. Частотная перестройка слуховой системы акустически активных бабочек-совок (Noctuidae, Lepidoptera) // Доклады РАН. 2002. Т. 386. № 3. С. 415-417.
3. Pigarev I.N., Nothdurft H.-Ch., Kastner S. Neurons with radial receptive fields in monkey area V4A: evidence of a subdivision of prelunate gyrus based on neuronal response properties // Exp. Brain Res. 2002. P. 199-206.
4. Podugolnikova T.A., Kondrashev S.L. Varieties of ganglion cells of the marine fish retina projecting to the optic tectum: an HRP study // Studia Marina. 2002. V. 23. № 1. P. 115-122.
5. Рожкова Г.И., Васильева Н.Н., Токарева В.С. Бинокулярная интеграция у детей дошкольного и младшего школьного возраста // Сенсорные системы. 2002. Т. 16. № 3. С. 221-229.
6. Rozhkova G.I., Podugolnikova T.A. Individual variability of accommodation in children with normal acuity of far and near vision // Ocular Biomechanics. 2002. P. 128-136.
7. Егорова Т.С., Голубцов К.В. КЧСМ в определении зрительной работоспособности слабовидящих школьников // Информационные процессы. 2002. Т. 2. № 1. С. 106-110.
8. Голубцов К.В., Орлов О.Ю., Аиду Э. А.-И., Софронов П.Д., Трунов В.Г., Егорова Т.С. Компьютерная система для диагностики зрения // Информационные процессы. 2002. Т. 2. № 1. С. 275-278.
9. Шигина Н.А., Куман И.Г., Голубцов К.В. Особенности использования импульсного хроматического света в диагностики хроматического света в диагностике и лечении атрофии зрительного нерва // РМЖ – Клиническая Офтальмология. 2002. Т. 3. Вып. III. С. 37-40.
10. Зуева М.В., Цапенко И.В., Голубцов К.В., Захарова М.Ю., Яковлев А.А., Хватова А.В. Диагностические возможности метода мультифокальной КЧСМ – В кн.: Клиническая физиология зрения. Ред. А.М. Шамшинова и др. М.: МНИИГБ им. Гельмгольца, 2002. С. 268-274.
11. Шигина Н.А., Куман И.Г., Голубцов К.В. Выбор и модификация методов диагностики атрофии зрительного нерва в условиях поликлиник. – В кн.: Клиническая физиология зрения. Ред. А.М. Шамшинова и др. М.: МНИИГБ им. Гельмгольца, 2002. С. 441-447.

In print

1. Кульчицкий С.В., Максимов В.В., Максимов П.В., Лемак М.С., Воронин Л.Л. Корреляция между парными ответами подтверждает наличие положительной эфаптической обратной связи в центральных синапсах // Доклады РАН. 2003 (принята к печати).
2. Лебедев Д.С. Компьютерная модель сети карликовых нейронов в центральной сетчатке приматов // Сенсорные системы. 2003 (сдана в печать).
3. Vedenina V.Yu., Helversen O.v. Complex courtship in a bimodal grasshopper hybrid zone // Behav. Ecol. Sociobiol. 2003 (in press).

4. Подугольникова Т.А., Носова М.Ф. Оценка уровня развития кратковременной зрительной памяти у дошкольников с нарушениями бинокулярного зрения // Дефектология. 2003. № 1. (в печати).
5. Максимова Е.М., Бастаков В.А. Физиология зрительного анализатора. – Руководство к практическим занятиям по курсу физиологии животных и человека. М.: Изд-во МГУ, 2003 (в печати).

Conference reports

1. Maximov P.V, Maximov V.V. Colour opponency by means of feedback from horizontal cells: a role of amplification by their nonsynaptic membrane // Perception. 2002. V. 31 (Suppl). 3. 137.
2. Maximova E.M., Vabishchevich A.P., Denisenko A.V., Maximov P.V., Orlov O.Yu., Maximov V.V. Directionally selective units in the goldfish retina: A colour-blind mechanism driven by two spectral classes of cones // Proc. of the 29th Goettingen Neurobiology Conference. 2002. Georg Thieme Verlag, Stuttgart, New York.
3. Lemak M.S., Maximov V.V., Maximov P.V., Koulchitsky S.V., Voronin L.L. Evidence for ephaptic feedback in mossy fiber-CA3 synapses: Positive correlation between paired responses // Proc. of the 29-th Goettingen Neurobiology Conference 2002. Georg Thieme Verlag, Stuttgart, New York.
4. Bastakov V.A. Two visual illusions associated with size constancy perception in frogs and toads // Abstracts of 32nd Society for Neuroscience meeting (Orlando, USA, November 1-7, 2002). Program No. 189.1. 2002 Abstract Viewer/Itinerary Planner.
5. Nikolaev D.P., Bozhkova V.P., Nikolayev P.P. Linear color segmentation and its implementation // Perception. 2002. V. 31 (Suppl). P. 67-68.
6. Николаев Д.П., Николаев П.П. Быстрый алгоритм выделения объектов, основанный на линейной модели формирования спектрального стимула // В сб.: "Искусственные интеллектуальные системы" и "Интеллектуальные САПР". Труды международной конференции IEEE AIS'02 и CAD-2002. М.: Физматлит, 2002. С. 410-416.
7. Nikolaev D.P., Nikolayev P.P. Estimation of reflectance properties following color segmentation (Colour constancy model using colour segmentation data) // Perception. 2002. V. 31 (Suppl). P. 138.
8. Prokhorov K.A., Nikolaeva G.Yu., Gordeyev S.A., Nikolaev D.P., Pashinin P.P. Raman structural study of polyethylene: the range of stretching vibrations of CH_2 group // Proc. of the Eighteenth International Conference on Raman Spectroscopy (ICORS 2002). 2002, John Wiley & Sons, Ltd., P. 711-712.
9. Голубцов К.В., Орлов О.Ю., Софронов П.Д. Новые средства диагностики в офтальмологии // Труды конференции "Научные исследования в наукоградах Московской области" (2002, г. Пущино). С. 62.
10. Орлов О.Ю.У истоков Института биофизики АН СССР (Персоналия) // Труды конференции "Научные исследования в наукоградах Московской области" (2002, г. Пущино). С. 106.
11. Андреев В.П., Трушкин Ф.А. Анализ телевизионных изображений в системе технического зрения робота "Крокус" // Мобильные роботы и мехатронные системы: Материалы научной школы-конференции (Москва, 3-4 декабря 2001). М. Изд-во Московского университета. С. 275.
12. Максимов В.В., Орлов О.Ю., Панютин А.К. Нейроэтология цветового зрения бесхвостых амфибий // Труды конференции "Научные исследования в наукоградах Московской области" (2002, г. Пущино). С. 98.

13. Голубцов К.В. Орлов О.Ю., Шигина Н.А. Устройство для диагностики глаукомы «АМЕЛИЯ» // Каталог V Московского Международного салона промышленной собственности "Архимед-2002". С. 45.
14. Голубцов К.В., Трунов В.Г., Айду Э.А.-И. Компьютерная система для диагностики зрения детей «КЧСМ-К» // Каталог V Московского Международного салона промышленной собственности "Архимед -2002". С. 46.

Patents and inventions

1. Golubtsov K.V., Kuman I.G., Khailo T.S., Bogdanova L.V., Sophronov P.D. Diagnostic method of visual function destruction and arrangement for its practical use. Patent on invention No. 2189168 // Bulletin of inventor No. 26 from 20.09.2002.
2. Golubtsov K.V., Sophronov P.D. Device for diagnostics optic nerve pathology at children, which determinate with critical flicker fusion frequency // Application for invention. Positive decision from 10.08.2002.
3. Golubtsov K.V., Orlov O.U., Shigina N.A. Device for diagnostics optic nerve pathology // Application for invention.
4. Golubtsov K.V., Sophronov P.D., Khuman I.G. Device for computer diagnostics in one side optic nerve atrophy // Application for invention.
5. Jiavelov I.S., Golubtsov K.B., Milekhin U.M. etc. Device for control of parameters of the cardio-vascular systems // Application with invention.
6. Golubtov K.V., Bubra V.I., Shamshinova A.M. etc. Device for registration a local electroretinogram // Application for invention.
7. Golubtsov K.V., Trunov V.G., Aidu E.A-I. Method of topical diagnostic of visual pole and arrangement for its practical use // Application with invention.

Diplomas and medals

1. Golubtsov K V. was awarded with Diploma and Medal of a prize-winner competition "Technique – a wheel-carriage of progress" which was lead by redaction of magazine "Inventor and rationalizer" (Moscow, 28 January 2002).
2. Golubtsov K.V. was awarded with Diploma and Medal of 5th International Salon of Industrial Property "Archimedes-2002" (Moscow, 27-31 March 2002) for construction instruments for optic nerve diagnostic, named "Ameliya".
3. Golubtsov K.V., Orlov O.Yu. were awarded with Diploma of consideration and acknowledgment for activity in organization and leading to 5th International Salon of Industrial Property "Archimedes-2002" (Moscow, 27-31 March 2002).
4. Golubtsov K.V. was a prizewinner of Gold medal and Diploma of International Festival of Innovation, Knowledge, and Creation "Tesla fest 2002" (Yugoslavia, Novy Sad, October 2002) for construction apparatus "Raduga-3".
5. Golubtsov K.V. was a prizewinner of International universal exhibition "Resources, ideas and technology-sight into EXPO-2010" (Moscow, VVC, 22-25 October 2002).
6. Golubtsov K.V. with co-authors were awarded with two Gold medal in 51st World Exhibition of Inventions, Research and New Technology "Brussels-Eureka 2002" (Belgium, Brussels, 3-11 November 2002) for construction the apparatus for blood pressure correction "Raduga-3" and apparatus for diagnostic a peritoneum.
7. Golubtsov K.V. with co-authors were awarded a Diploma for active participation in forums and a Medal for apparatus "Raduga-3" in 1st Russian – Cyprus forum "Inventions and scientific discoveries in the XXI century" (Cyprus, Nicosia, 24 May – 2 June 2002).
8. Golubtsov K.V. was a prizewinner of Silver Medal for construction apparatus "Raduga-3" in Seoul International Invention Fair 2002 – "SIIF 2002" (Korea, Seoul, 4-8 December 2002).