1862

RIGA TECHNICAL UNIVERSITY

VICTOR MIRONOV

In Search of Innovation

The Evolution of Technical Thought

Professor, Doctor of Engineering Sciences

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The book “In Search of Innovation” has been conceived to commemorate the 60th anniversary of the professional career of Professor Victor Mironov and the 50th anniversary of his academic career at Riga Technical University. The book presents a digest of the most important scientific achievements and inventions made by the author, as well as the bibliography of the most significant papers published in Latvia, Germany, Russia, Belarus and other countries from 1970 to 2018. In his book, Professor Mironov reflects on the most significant events in his life, remembers encounters with the people who in some way influenced his professional and academic career, and pays tribute to his family, friends, colleagues and students, who supported and inspired him in his search of innovation.

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List of Abbreviations

RTU – Riga Technical University
RPI – Riga Polytechnic Institute
RSY – Riga Shipyard
PM Lab – Laboratory of Powder Materials
TSTU – Tver State Technical University
IPM – Institute of Powder Metallurgy of the National Academy of Sciences of Belarus (Minsk)
LAWS – Latvian Association of Welding Specialists
IMRM of NAS of Belarus – The Institute of Mechanics and Reliability of Machines of the National Academy of Sciences of Belarus (Minsk)
SSAU – Samara State Aerospace University
MEPhI – Moscow Engineering Physics Institute
PPPM – Pilot Plant of Powder Metallurgy (Riga)
TsNIIMash – Central Research Institute of Machine Building (Leningrad),
KAI – Kuibyshev Aviation Institute (Kuybyshev)
KhPI – Kharkov Polytechnic Institute (Kharkov)
UASZ – University of Applied Sciences Zwickau (Zwickau)
VEF – State Electrotechnical Factory (Riga)
RER – Riga Electric Machine Building Works (Riga)
LAWS – Latvian Association of Welding Specialists
LAMSS – Latvian Association of Materials Science Specialists
PPMR – Plan of Preventive Maintenance and Repair
SCG – surge-current generator
PEF – pulsed electromagnetic fields
MPSP – magnetic pulsed compaction of powders
MPPM – magnetic pulsed processing of materials

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- Administration of Riga Technical University (RTU), especially to the staff of the Chair of Metal Technologies and the Laboratory of Welding Process Automation at the Faculty of Mechanics and Machine Building for their support at the initial stages of research (1969– 1972);
- Staff of RTU Faculty of Civil Engineering, especially the staff of the Chair of Construction Operations, for their help in my teaching and pedagogic mastership training (since 1972 until present).
- Staff of the Faculty of Mechanical Engineering, Transport and Aeronautics for their support and cooperation (from 1972 until present).
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marketing of materials and equipment, as well as in the field of international cooperation (1995–2004).

- Staff of the Institute of Powder Metallurgy of the National Academy of Sciences of Belarus (Minsk) for assistance in development of scientific research and cooperation (from 1970 till now).
- Staff of NIL-41 Lab of Samara State Aerospace University, the Chair of Physical Materials Science of the National Research Nuclear University MEPhI, Tver Technical University (Russia), University of Applied Sciences Zwickau (Germany), Dresden University of Technology, and other, for cooperation in different technical domains.
- Friendly collective of the united volleyball team of RTU and VEF veterans (1995–2010).

I would like to express my deep gratitude to my parents, relatives, and friends for support they offered me on the interesting, yet hard path of an engineer, researchers and teacher.

Special and great thanks go to my wife Vera Pavlovna Mironova for her understanding and permanent support.

I would like to extend my thanks to almost 4,000 students of mine, who attended my lectures and developed their laboratory works and diploma papers. I will be glad to know that they are applying the acquired knowledge and experience.

Author's Preface

Time flies. Years and decades rapidly go by. Life is changing. Today younger people, who I live and work with, consider the events that took place 20 or 30 years ago as outdated and boring. However, people of older generations know perfectly well that many things repeat and almost nothing starts with a clean slate. Everything has its reason rooted in the past.

This book is mainly dedicated to discussion of technical matters, as the author has been dealing with them for his entire life, but this is not the whole story. Behind all technical solutions and activities, there are real and living people with their relations and emotions. The book describes the periods of growth and stagnation, the period of hope and deep changes in the times of "perestroika", although one thing remains permanent and unchanged – co-operation, strife for the new, optimism and belief in the power of reason.

This book has been conceived to commemorate the 60th anniversary of the author's working career and the 50th anniversary of his career at Riga Technical University. It tells about the milestones of his industrial, scientific research, academic, pedagogical, and social activity.

The book presents a digest of the most important scientific achievements in the author's view, as well as the bibliography of his most significant papers in different publications in Latvia, Germany, Russia, Belarus and other countries from 1970 until 2018. Certain sections contain information about the author's co-inventions and patents, his scientific reports and dissertations.

Bibliographic data is arranged into sections chronologically. Each section presents the main scientific achievements and published works.

The book provides information about main lectures delivered by the author in different times at other universities and organizations, as well as information about the educated and trained Bachelors, Masters and Doctors.

Many publications are also available on the web-sites http://rtu. ortus. lv and http://izgudrojumi:lza.lv/izg. php?id=34

1. Professor Victor A. Mironov

Biographical Essay

Victor A. Mironov, Doctor of Science, Professor
at Riga Technical University and an Honoured Inventor
of Latvia is well-known for his achievements in the field
of powder metallurgy, materials science
and mechanization of construction works.

V. A. Mironov was born on October 7, 1941, in Kalinin (now Tver). In 1959, after graduating with honors from the Kalinin Wagon School, he began his career at the wagon works in Torzhok (Kalinin Region). In 1965, he graduated from the Department of Mechanics of Kalinin Polytechnic Institute and received a degree in engineering. The viva voce procedure for the diploma was conducted in German. From 1965 to 1968, after graduating, V. A. Mironov got an appointment as an engineer for industrial equipment repair at Riga Shipyard of the Ministry of the Maritime Fleet, USSR. Here he proved himself an active innovator and promising young professional. In 1968, V. A. Mironov enrolled in Doctoral program at Riga Polytechnic Institute (now Riga Technical University) and started working as a junior researcher at the laboratory of the Department of Electrical Engineering under supervision of E. K. Yankopa (Candidate of Technical Sciences). From 1969 to 1972, V. A. Mironov worked on his Thesis for obtaining the degree of the Candidate of Technical Sciences “Investigation of the Production of Sintered Parts Using Pulsed Electromagnetic Fields” (supervisors: Dr. O. V. Roman and Dr. O. Y. Vacietis), which he defended in 1972.

This period marked the beginning of Mr. Mironov’s active work on the development of a new branch of materials processing technologies – development and use of new technological processes using strong pulsed electromagnetic fields, researching their effect on the structure and properties of materials. During his study years, V. A. Mironov was repeatedly awarded with diplomas and certificates of honor by the Ministry of Higher Education of Latvia. Active cooperation with the colleagues from Riga Electric Machine Building Plant, which was led by a renowned expert and organizer Dr. A. I. Godes, allowed establishing an experimental laboratory for magnetic pulsed compaction of powders. The methods for obtaining pseudo-alloys iron-copper by infiltration of powdered materials metal melts were developed at this laboratory. The equipment and accessories for magnetic pulsed compaction of powders of hard alloys and pulsed magnetic deformation of powder parts were also developed, as well as many new processes, including construction of the world's first magnetic-pulse treatment plant for powder and composite materials.

In 1972, Mr. Mironov began his teaching career at the Department of Building Production at Riga Polytechnic Institute, and made his academic path from a senior instructor to the position of a professor. He delivered lectures and managed practical training within such study courses as "New Materials", "Machine Parts", "Conveying Machines", "Construction Machinery", "Mechanization of Construction Processes", "Specialized Road Transport in Construction", "Welding Technologies and Equipment in Construction" and many other. In 1974, while still on the job, Mr. Mironov graduated from the Teaching Excellence program of the University of Latvia.

In 1974–75, Mr. Mironov underwent scientific internship in Sweden. During the year of studies in Sweden under supervision of Professor G. Fishmaister, Mr. Mironov was engaged in research of powder metallurgy, hot-forging and stamping of powders. In the 1970's, Mr. Mironov was actively involved in invention activity. During this period, he received more than 30 inventor's certificates for new equipment design for powder densification, equipment and methods of sintering of powder materials, new powder and composite materials. He actively involved the staff of his Chair, the specialists of the Society of Inventors of Riga Polytechnic Institute, in creative and inventive activities. Mr. Mironov was awarded a badge "For Excellent Inventive Work", and received the medals of the Exhibition of Economic Achievements of the USSR. In 1982, Mr. Mironov received the honorary title "Honored Inventor of the Republic of Latvia".

In the early 1980's, a new period of activity Mr. Mironov began, it was associated with the long-term cooperation with the German scientists from the cities of Wismar, Dresden, Ulm, and Zwickau. He was actively working on international cooperation, carried out research in laboratories abroad, and actively participated in many international conferences and symposia in Austria, Denmark, Poland, Germany and Yugoslavia. Scientific papers developed by Mr. Mironov made him a renowned scientist not only in the Soviet Union but also abroad. He was the head of the Bureau of Powder Technology of the USSR MIOM SCST Section, a member of the Powder Metallurgy Council of the Ministry of Higher Education of the USSR, Chairman of the Section of Powder Metallurgy of Mashprom Latvia, a member of the International Association "Compound Materials", Denmark, etc.

At this time, under the leadership of Prof. Mironov and with his direct involvement research in the theory and technology of pulsed electromagnetic fields used for compaction of a large class of materials ranging from metal powders to armoured cements and ceramics was conducted at Riga Polytechnic Institute, Research Institute of Powder Metallurgy of Belarus, VPTI Elektro, Zwickau Technical High School and other research centres. During the investigation, the principles of macro and micro-structure of powder blanks by magnetic pulsed compaction, the methods of registration of pulse compression parameters using ultra-fast filming, and a new method of estimating the pressure of a pulsed magnetic field were developed, the patterns of distribution of material properties in the bulk of the work-piece were established. In this period, many new materials were obtained, such as variable-permeability powder materials, coated metal melts, composites of fibrous powders and super-hard materials.

The scope of research, the number of innovative solutions and their effective application in 1980 allowed Mr. Mironov to complete his Doctoral Thesis "Magnetic Pulsed Compaction of Powders and its Application in Technological Processes", which was successfully defended in 1986 at Moscow Institute of Fine Chemical Technology. Mr. Mironov obtained a Doctoral degree in powder metallurgy and composite materials.

The results of these studies were reflected in more than 250 scientific publications, several monographs and descriptions of 160 USSR author's certificates for inventions, more than 30 patents in Russia and Latvia.

Along with the fruitful scientific activity, Mr. Mironov has conducted pedagogical and academic work with students and graduate students at Riga Polytechnic Institute since 1972. His lectures in the field of welding, mechanized construction, pulse technology, and recycling of technological waste reflecting on the latest advances in materials science and construction are of considerable methodological value and are characterized by high pedagogical standards. Under his leadership, educational and research laboratories "Automotive", "Machinery Parts", "Cranes and Construction Machinery" "Pulse Technology and Powder Metallurgy" were established at the Department of Building Production of Riga Polytechnic Institute. Mr. Mironov developed several teaching aids, both individually and in collaboration with foreign scientists. In 1988, by decision of the HAC of the USSR Doctor of Technical Sciences Mironov received the rank of the professor. In 1994, Victor Mironov was awarded the title of the Habilitated Doctor of Engineering Sciences (Dr. habil. sc. ing.), and in 2001 – the title of Professor of Riga Technical University.

The works of Prof. Mironov are characterized by the in-depth study of the issues related to magnetic pulse compaction of powders, in addition, he addressed a wide range of related problems. For example, under his leadership and with his active participation the so-called fibrous powders Al-W-B have been obtained, a method for steel fiber mesh for armor cement products has been proposed, automatic dosing of powders, the new diamond-abrasive elements for cutting and grinding stone and concrete, implants made of powder compositions for the hip joints have been developed.

Prof. Mironov is renowned not only as a distinguished scientist but also as a popularizer of science. In 1974, he wrote an interesting popular science book "Magnetic Pulse Works" (Riga, 1974), which has been translated into Latvian and German. At his lectures for undergraduate and postgraduate students, Prof. Mironov pays a lot of attention to the history of technological development, especially in the field of materials science, construction and road engineering, and transportation. He is a member of the Union of Latvian Scientists.

Professor Mironov has continuously advanced and widened his language competence. For example, he developed lecture notes and manuals for laboratory works in the Russian and Latvian languages for students majoring in construction and engineering, developed and published several 4-language illustrated dictionaries of terms in such areas as building machines, welding, and machine parts. Professor Mironov delivers his lectures in Latvian, Russian, German and English.

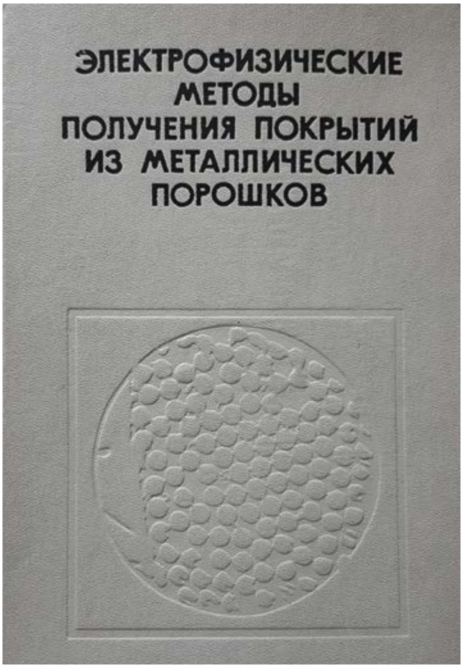
From 1994 to 2004, Professor Mironov was the representative of the Swedish company Höganäs, the world's largest producer of iron and steel powders, in Russia, other CIS countries and the Baltic countries. He organized and conducted numerous seminars on the production and use of metal powders, which gathered scientists and professionals from the leading manufacturers of powder parts.

Professor Mironov annually visits Tver State Technical University, his *alma mater*, participating in the conferences and seminars organized by the university. He used to deliver lectures and supervise internship of the students organized at Wagon Building and other plants. Also at present, he regularly exchanges his teaching experience with the colleagues from this university. In the period from 1990 to 2010, Professor Mironov repeatedly lectured as an invited professor at Vienna University of Technology (Austria), Technical University of Gothenburg and Linköping (Sweden), technical universities of Dresden, Zwickau, Wismar, Ulm, Munich (Germany), National Research Nuclear University MEPhI (Russia), and Belarus National Technical University.

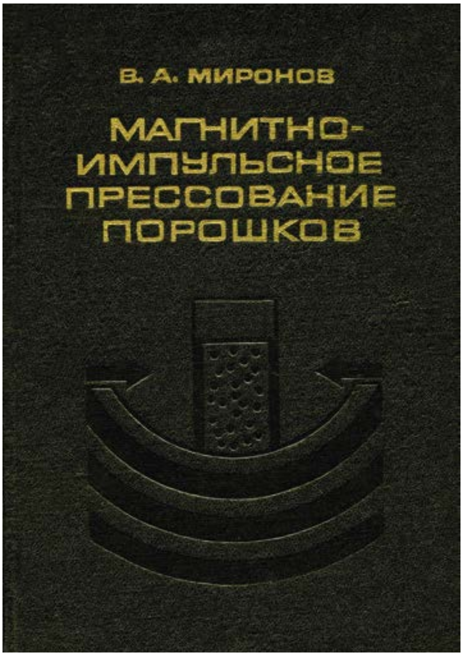
Since 1990, Prof. Mironov has headed the Section "Metallic Materials" of the Latvian Materials Research Society. He is one of the organizers of the Baltic Association of Materials Research Scientists. Simultaneously, he heads the Section "New Welding Processes and Equipment" at the Society of Welding Engineers of Latvia. He used to be the Chairman of the Organizing Committee of the International Conference MET (Metals, Welding and Powder Metallurgy), which was regularly held in Riga and Jurmala from 1994 to 2013. Prof. Mironov repeatedly advanced his professional qualification and improved his foreign language skills during research traineeships in Sweden, Germany, Belarus and other countries.

Professor Mironov is also known for his work in the field of ecology and environmental protection. Together with other members of RTU staff, he took part in the development of ferromagnetic sorbents for the removal of water-spilled oil, the electromagnetic elevator for powder materials, techniques for practical use of waste steel perforated tape, new materials and products from waste fiber composites Al-W-B. For these achievements, Prof. Mironov received more than 20 patents in Latvia and Russia.


Миронов Виктор Александрович
Пузырев Николай Михайлович
Кочканян Сейран Микаелович
Механизация строительных процессов


ЭЛЕКТРОФИЗИЧЕСКИЕ МЕТОДЫ ПОЛУЧЕНИЯ ПОКРЫТИЙ ИЗ МЕТАЛЛИЧЕСКИХ ПОРОШКОВ


Viktors Mironovs
Mihails Lisicins
Perforētie metāla materiāli un to izmantošanas iespējas
RTU izdevniecība


В. А. МИРОНОВ
МАГНИТНО-ИМПУЛЬСНОЕ ПРЕССОВАНИЕ ПОРОШКОВ

In his respectable age, Prof. Mironov continues to be an active and talented scientist, skilled teacher who knows how to pose and solve new urgent problems, how to motivate and involve employees, how to foster creativity of postgraduate and Doctoral students. Due to their efficiency, enthusiasm, creativity, organizational talent, and goodwill, he has deserved respect and devotion of colleagues and students. His name is a standard of credibility among scientific experts working in the field of powder metallurgy, electric pulse technology, and mechanization of construction.

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4. First Steps to Understanding Science

During the period after World War II (WWII), many families in Europe had to survive, arrange some basic accommodation and feed their children. As a rule, parents worked much and hard, but children spent almost all their time at school or playing outdoors.

I spent the years of my childhood and adolescence in the city of Kalinin (now the city has regained its original name Tver). It is a large industrial city in Russia, located on the way between Moscow and St. Petersburg (called Leningrad at that time). In spite of being under German occupation only for 2 months, the city was severely damaged during WWII. My father – Alexander Ivanovich Mironov – graduated from the Leningrad Engineering Construction Institute just before the war. During the war, he worked in the Urals Region – he was building a plant in Perm. In 1943 he returned to Kalinin, where he took part in the restoration of the Kalinin Carriage Works. Later on, he taught civil engineering at the Kalinin Carriage Building College.

My childhood moments are still very bright. They are engraved in my memory forever. I remember how much astonished I was when I saw the process of wood lathing. A carpenter was lathing a stool leg. Woodturnings were curling, either

Kalinin (Tver). Bridge over the River Volga,1942.

My father –
Alexander Mironov, 1942.

producing nice shavings or chipping away. The carpenter explained – if the material is soft, the turnings will curl, but if it is hard, it is brittle and thus it will chip away. At that time, I craved to be a lathe operator.

Oddly enough, but a lot of things begin with a sand-pit where you play in your childhood. If you fill a bucket with sand, turn it upside down, and hit the bottom of the bucket – here you are – you get a sand pie. But it is crumbling down and is shaped badly. Whereas a boy sitting next to me (for some reason wearing glasses with a blind on one glass) has a steady and even heap. It turns out that everything is pretty simple – you just need to slightly wet the sand.

My parents were building a house. We, boys, were observing the building process in passing, but I remember a lot. For instance, logs had large letters and numbers on them. It appeared be the marking. The house was moved from the village to the city. First it was disassembled, though not in a rough-and-ready

Volga-Don Canal, 1954.

manner, but by carefully marking every log and plank to make it easier to reassemble the construction in the new site.

My grandfather was a top expert in gypsum plastering. He knew well how to make gypsum plaster for the ceiling and how to make it durable. It was very interesting to see grandfather mixing gypsum mortar and casting it into a wooden form – case. Then, after drying, he dismantled the form and achieved a magnificent fragment of gypsum for ceiling decoration. That was my first encounter with construction materials.

After classes, we used to walk in search of the remnants of war. We found rounds, gas masks, pots and platoon helmets. We also played one dangerous game – launched different bits into the sky with a slingshot. Boys confidently used such terms as *trajectory*, *angle*, *speed* and *acceleration*. Who knows, maybe those very "hobbies" afterwards led me to research into impulse processes.

I was greatly impressed by the first trip along the just opened Volga-Don Canal. I was awarded a diploma and this trip for good study in the 6th grade and participation in the competition of ambulance teams among the schools of the city. Our squad won the 1st place

5. Technical College

In the mid-1950's, only ten years after the end of the war, many boys of my age did not even think about higher education. In most cases, they went to technical colleges or industrial schools. That gave opportunity to both get a profession and start living on one's own.

I entered the Kalinin Carriage Building College immediately after finishing the seventh grade at school. The technical college was founded in 1949 based on the Kalinin Carriage Building Works. My elder brother Vyacheslav had been already studying there at the Department of Civil Engineering. However, my father said, "Your brother, same as me, will be a builder, better be a metal worker". So I went to the Department of Mechanical Engineering and Metal Working.

We were taught well, in a truly comprehensive considerate way; it was entertaining. The technical college received some captured trophy equipment as war reparations from Germany. We disassembled machine units, cleaned, washed the parts in kerosene, took part in assembly works and start-up. The machines were installed on their foundations using anchor bolts and cement mortar. The discipline at the college was very strict. Many teachers had recently returned from the front line and had just taken off their shoulder boards, and still were wearing

The building of the Kalinin Railway Engineering College at 12 Mussorgsky Street.

A group of graduate students and teachers after graduation from the Kalinin Railway Engineering College, 1959.

officer map cases on the side. They thoroughly prepared for the classes. The students managed their lecture notes with equal diligence, as there was almost no textbooks. We spent much time at the library. Great importance was ascribed to practical works – we developed the skills and competences of metalworkers, lathe operators, mill operators and drafters.

I still remember much about the times of my technical college studies. I remember the head of our group – Alexander Fadeyev and the Komsomol secretary Galina Tarasova. Our group was a real tight-knit team. We were united by common interest in studies and sports, but our ties became especially strong during annual missions to collective farms organized in September-October to help in harvesting. In 1957, during one of the nights at the collective farm, we breathlessly observed the flight of the first Earth satellite. We remain friends with many of my group mates until now. Many technical ideas I have developed are rooted in those times. I have also not forgotten many important conclusions:

- the quality of work is often more important than the speed of execution (during internship, you could execute your work fast, but a strict master would not compliment you, he would give you a lower grade instead);
- you should be very careful with equipment and tools, because if a part is fixed badly, during machining it can be ejected, and a wrench left in the drive chuck of the machine can cause serious injury;
- work tools must be well and correctly sharpened and stored in one special place;
- you need to know the machined material as well as you can.

We rarely cut classes and made lecture notes very carefully. I very well remember many of my teachers: Alexander Versin (physics), Yury Pletner (cutting tools), Irina Vladimirovna Rajevskaja (materials science and engineering).

6. Early Career

My working life started at the factory in the town of Torzhok in Kalinin (Tver) Oblast, where I was delegated together with a small group of other graduates of the Kalinin Carriage Building College in 1959. The factory in Torzhok was a branch of the Kalinin Carriage Building Works. It was the time of the arms race and the Torzhok Factory produced railway carriages for rocket transportation.

On the outside, the carriages did not differ much from the common steel passenger cars, but at the rear end, there were push open doors letting a special 15 m long cart roll out. This cart was envisioned for the installation of a rocket with its launching equipment.

I started working as a metal turner at the machining workshop. The work was hard, because I was only 18 years old. Night shifts were particularly difficult, they lasted from 11 p. m. until 7 a. m. The hostel was overcrowded, so I had to rent a room with three other roommates.

The factory was equipped with a mixture of different types of machines. Some machines were delivered from Germany, other returned from the evacuation in the Urals region. The factory staff welcomed us, young colleagues, very warmly, we could learn much from the skilled workers and professionals. The quality of work was a matter of great attention, as the products were checked by experts – representatives of the military– at all stages of their manufacturing.

Torzhok is a really ancient town in Russia. Its origins date back to 8–9 century A. D. There are many churches, the friary, some historical and architectural museum complexes, sites connected with the life and work of a prominent Russian poet Alexander Pushkin. However, in general it is a quiet and very provincial town. This is where my family life started, joining me in marriage with my wife Vera. We studied together at the technical college, together we were sent to work to the factory, and later we studied at the same institute, and since that time we have been walking hand-in-hand throughout our entire life.

The factory management actively encouraged efficiency improvement. One of my hostel mates was also a graduate of the technical college. He shared his idea with me – he wanted to arrange the lighting at the factory so that the lamps would switch on at nightfall and switch off after sunrise. He developed an innovation proposal and the Chief Engineer of the factory invited him for discussion. Soon he moved to the engineering unit and his project was implemented. I dreamed about a similar career, I tried to be innovative while working as a turner. Some months later, I learned that the workshop manager did not want to let me go. He wanted me to become a turner of high qualification – back then we already knew about automated machines and robotic centers.

I recollect the meeting with Grigory Lednev, a young engineer from the engineering unit of the works. He graduated from Bauman Moscow State Technical University and organized the Council of Young Specialists at the factory. I still remembered one of the things he said: a technician should learn throughout his entire life, because the development of technical equipment and technology never ends.

7. Undergraduate Studies

I wanted to continue my studies. In 1960, I entered the extramural department of the Faculty of Machine Building of Kalinin Polytechnic Institute. The Institute had been recently relocated from Moscow to Kalinin. Certain part of the teaching staff came from the Kalinin Carriage Building College; there were also many young graduates of several Moscow universities. To avoid military service I decided to enroll in full-time studies. By that time, my wife and I had returned to our native city Kalinin. According to the terms of employment, I had to work at the factory for three years, but thanks to the fact that I graduated from the technical college with honors, one year of work turned out to be sufficient.

During my studies, a new method of learning was implemented at our institute – education was coupled with the on-the-job training, that is, work at the factory. Two weeks of studies were followed by two weeks of work at the factory. As a rule, we worked at the Kalinin Carriage Building Works. Over the years, I

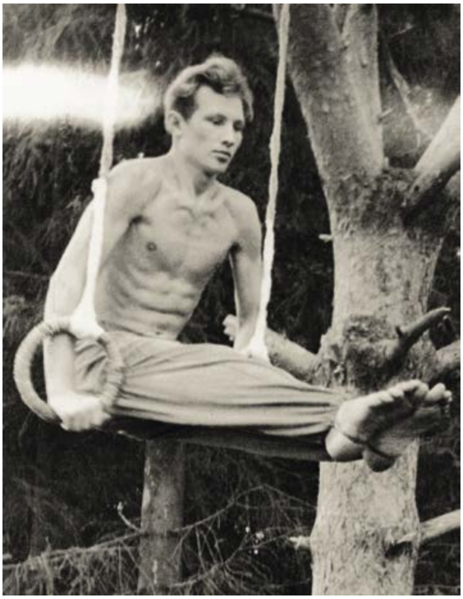
Kalinin Polytechnic Institute. Russia.

had to work as a technician in the pipe workshop, as a grinder in the forge shop, as a lathe operator in the mechanical workshop, and as a molder in the foundry shop. My studies lasted for the entire week including Saturday and I had to work the whole shift at the factory. Still, at that time we took it as a matter of course. We managed to get a proper rest and even to do sports. For example, I went in for artistic gymnastics. I also started taking lessons in the seven-stringed guitar at the musical studio.

During the third year of studies, Olga Nikolayevna, our teacher of German, offered me a job at the Student Translation Bureau. I received only a modest wage there; however, it was a rare opportunity to use my intellectual abilities instead of unloading carriages at the railway station, which we did sometimes to earn some money. Translations were commissioned by the chairs and the Research Department of our institute. By that time, my wife Vera had also entered the Institute, although she had to study at the night department, as she already successfully worked at the engineering design bureau of the Carriage Building Works. We needed money for living, because my income was made only of the bursaries, albeit premium ones, and my part-time translation activity did not bring a regular income. It was a very difficult period, as my wife Vera left home at 7 o'clock in the morning, and came back from studies late in the evening, sometimes even at 10 p. m.

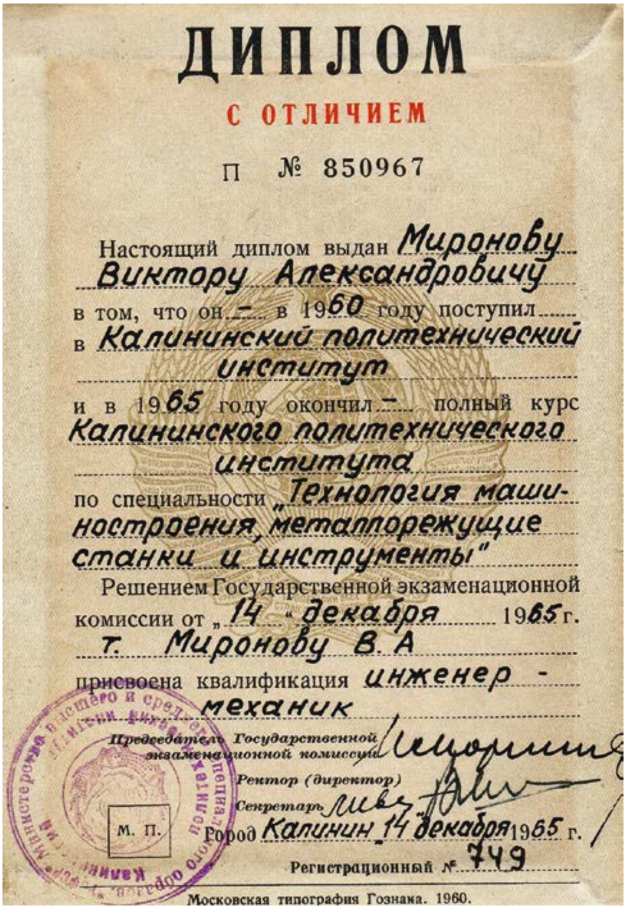
I publicly presented my Diploma in Engineering and Mechanics in German. That was an experimental and demonstrative *viva voce*, which passed smoothly. The Diploma Project was related to the development of a specialized workshop

Students of Kalinin Polytechnic Institute, 1965.



Gymnastics, 1962.

Vera and Victor Moronov. Starting together.


ДИПЛОМ

С ОТЛИЧИЕМ

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Настоящий диплом выдан Миронову Виктору Александровичу

в том, что он – в 1960 году поступил в Калининский политехнический институт

и в 1965 году окончил – полный курс Калининского политехнического института

по специальности „Технология машиностроения, металлорежущие станки и инструменты"

Решением Государственной экзаменационной комиссии от „14" декабря 1965 г.

т. Миронову В. А

присвоена квалификация инженер-механик

Председатель Государственной экзаменационной комиссии

Ректор (директор)

Секретарь

М. П.

Город Калинин 14 декабря 1965 г.

Регистрационный № 749

Московская типография Гознака. 1960.

Engineering Degree, 1965.

of gear wheel production for Kalinin Excavator Plant. My project supervisor was a teacher of our institute Alexander Sak-Shak, who moved to Kalinin from Riga where he had worked for several years. I think that his stories about this city significantly influenced my choice of my future employment.

In parallel with the diploma (with honors), I received a statement of certifying the pass of the Ph. D. candidacy examination in German, which exempted me from such an examination in future upon enrolment in postgraduate studies.

During my studies at the institute, my first innovation proposals were developed. Of course, they were related to the organization of work at the factory: a drilling machine to cut three holes in pipefittings simultaneously, an alarm switch to switch off the drilling unit in case of a seized bit, etc.

8. On-the-Job Training

After graduation from Kalinin Polytechnic Institute in 1965 as a young specialist with honors I was sent over to Riga Shipyard under the Ministry of the Maritime Fleet. Thus, I started my working life at one of the best industrial workshops of Riga. It was the period when the shipyard was developing fast: new berthing facilities were built, a new modern docking facility with load bearing capacity of 27 thousand tons was delivered from Finland, its foundry and mechanical workshops were upgraded, a compressor and an oxygen station were built. I worked at the shipyard at the Department of the Chief Mechanical Engineer, in the position of an equipment engineer. The equipment was very diverse – hydraulic and mechanical presses, turning lathes for processing of marine drive shafts, pumps, compressors, various welding equipment, travelling and bridge cranes – over 6,000 items altogether. A lot of equipment was unique, for instance, a machine for processing propeller screws, a chain test bench, a rubber collar press, etc. They had to function without failure, otherwise a ship could stay on repair for long. That is why we had to plan maintenance and repair very thoroughly, ensure supply of the spare parts

While working at the Shipyard. Riga, 1967.

Working at the Department of the Chief Mechanical Engineer at the Riga Ship Repair Plant, 1968.

in advance, but complete the maintenance and repair fast and in a package – with several maintenance teams (mechanics, electricians, builders) working together. It often happened that maintenance and repair included upgrade of equipment, as many of the machines were out-of-date, built in the pre-war period.

I kindly recall my tutors at the shipyard: the Chief Mechanical Engineer Georgy Kuznetsov, the Chief Power Engineer Alexey Dubov, the head of the Maintenance and Repair Works Alexander Shablinsky, an equipment engineer Nikolay Muranov, a design team manager Isaak Stavicky and many others. The Chief Mechanical Engineer Kuznetsov was strict, competent, and strong-minded. He was a good manager and a trained engineer. He paid a lot of attention to work place environment of his employees – young engineers. I remember that when we entered his office he often asked strictly, “Where is your work notepad? You shouldn’t rely on your memory, but should diligently make your notes. ”

Meeting of old friends (Mironovs, Stavitsky and Maximovs), Riga, 2015.

At the end of the 1960's, the shipyard was actively reconstructed and expanded – new service premises were built, the equipment was upgraded. New up-to-date bridge cranes, lifts and loaders appeared.

As young specialists, we received a warm welcome, and almost immediately were provided with accommodation. Me, my wife and daughter also got our first home – a room in a shared apartment in the shipyard street.

The shipyard managers greatly supported innovative and efficiency advancement solutions coming from the general and engineering staff, but those could not be just "bare" ideas. Rewards were paid only after real implementation of innovations. My first proposals on efficiency advancement were related to upgrade of machine equipment and ventilation systems, enhancement of durability of machine tools.

A huge role played by the shipyard's Komsomol organization should be noted. At that time it was led by Gennady Malinovsky. We have been friends ever since. Nowadays, Komsomol is hardly ever referenced positively. But in the 1960's and 1970's, Komsomol was a real mentor for the youth. We did not attend any political lectures or participated in many hours of meetings. I recall numerous raft tours along the Gauja River in spring, travels to Tallinn, Brest and the Carpathian

Mountains, mountain trekking in the Caucasus, and, of course, contests of young workers – lathe operators, mechanics, and welders.

The shipyard was situated in a remote area of Riga away from the center – Vecmilgravis. Most of the residents were Russians. Some of the managers and workers were Latvians, but all of them spoke Russian perfectly. In the first months of my stay, I bought a book by Veksler – a self-study book of the Latvian language, although many of my colleagues were surprised why I did it. Latvian was seen as a regional language for local residents, which would unlikely appear useful. However, no doubt, that was a great mistake of the leadership of the then Soviet Republic of Latvia, and of course, of the shipyard's public organizations.

The shipyard had an advanced engineering design bureau employing many young specialists – graduates from Odessa Institute of Marine Fleet. A young and dynamic Odessan Alexander Polyakov stood out among them. Subsequently, he enrolled in the Doctoral studies, developed and defended his thesis. Even then, he was interested in the issue of fuel production and combustion. He dedicated many years to elaboration of special units – dispersants. Another former shipyard employee – Victor Gavrilov – became a Doctor of Physics and Engineering Sciences and afterwards worked at the nuclear power station in Salaspils. Youry Maksimov, my fellow student, became the Chief Engineer at Riga Experimental Plant of Powder Metallurgy in the 1980's.

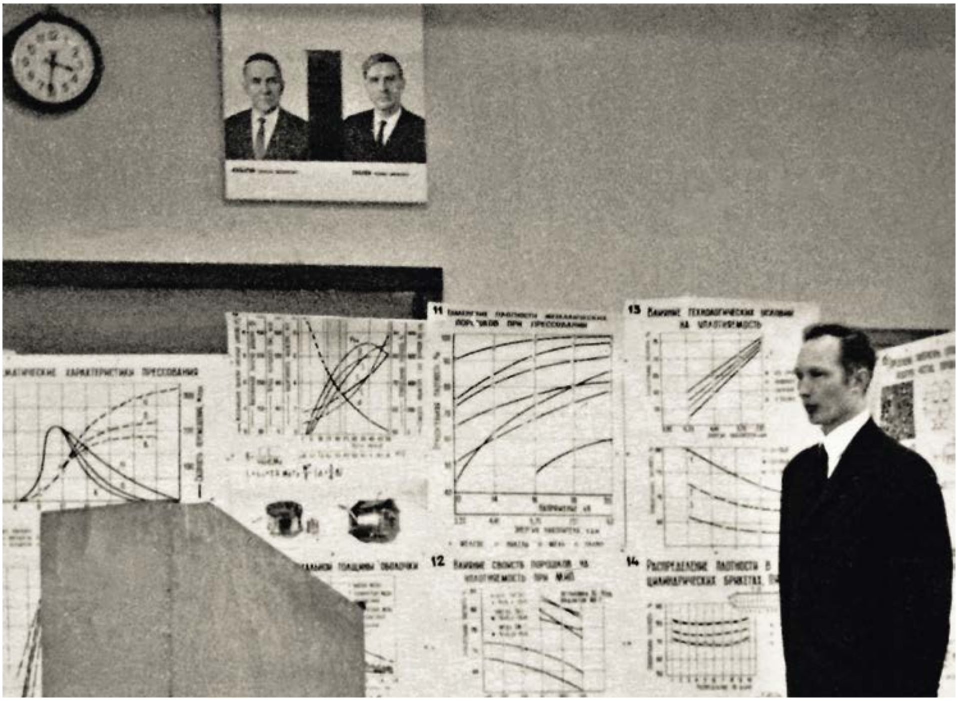
It was an established practice at the shipyard that young specialists had to regularly undergo training to advance their professional qualification. Some of the courses that I attended were related to repair of industrial equipment; they were organized at Riga Polytechnic Institute. The gained knowledge greatly helped me in my work. As a senior engineer of the Department of the Chief Mechanical Engineer I had to know and control the functioning of equipment of the entire shipyard. And it was quite diverse: metal cutting machines, metal-forming and gas-cutting equipment, cranes, lifts, and pumps. Maintenance and repair had to be based on an up-to-date model. There was a clear instruction – emergency repairs should not occur. So we drew up a very scrupulous plan of maintenance and repair works (PMRW) beforehand. According to PMRW, we had to order and manufacture spare parts, decide on the times of repair stand-by, fit thoroughly maintenance and repair deadlines, and upgrade the equipment.

At the courses, I learned about the technology of powder metallurgy. We visited the first powder detail production station, which was established at Riga Electric Machine Building Work*s (*RER*)*. The station was located in the specialized engineering design bureau of powder metallurgy, and at that time it was led by a devotee, very skillful professional and manager Alexander Godes. Afterwards he became the first director of the Pilot Powder Metal Production Plant (PMP).

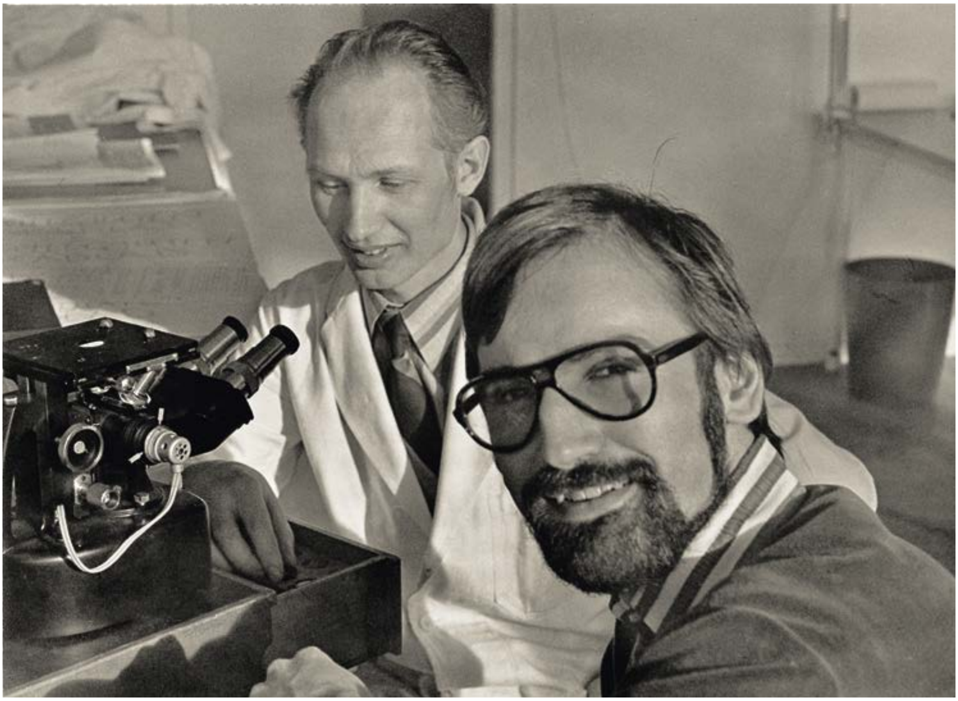
9. First Steps in Science

I reflected seriously on the feasibility of my enrolment in the Doctoral studies. On the one hand, I successfully worked at the shipyard, but on the other hand I vividly felt the strife for finding new solutions. Responding to my efficiency advancement proposal, the shipyard had already purchased an electrospark frame coating unit for frame reinforcement. I had an idea to use that method to reinforce frames of other equipment. The principal task was to reduce their wear and tear during operation. However, I needed deeper knowledge in materials sciences. Thus, I addressed to the Chair of Metal Technologies of Riga Polytechnic Institute and its experienced materials science specialists – Vladimir Pehovich, Arvids Shteinbergs, and Youry Panteleyev. In the next few months our frame reinforcement bench was successfully launched at the shipyard.

At that time I received a real offer to apply for Doctoral studies. The Vice-Rector for Research of Riga Polytechnic Institute Ojārs Vācietis became the supervisor of my thesis. It should be mentioned though that the theme he suggested was not directly related to powder metallurgy. It was the time when



Viva voce of the Doctoral Thesis, Riga Polytechnic Institute, 1972.



Victor and Olaf. TU Chalmers, Sweden, 1974.

an assistant professor Ēriks Jankops set up a group of Doctoral students to implement a large project on the use of pulsed electromagnetic fields for pipe deformation and assembly at RPI Faculty of Power and Electrical Engineering. It was a commercial order, which RPI received from Vyborg Shipyard.

Strong electromagnetic fields, sufficient for steel and copper pipe pressing, could be obtained at high voltage (up to 10 thousand volts) at the moment of electrical discharge. We had to elaborate an effective and reliable energy accumulator based on the series of specified pulse capacitors, as well as a reliable inductor assembly. In the next few months, our first electromagnetic pipe deformation unit was produced and sent to the Customer.

Further I started working on the themes within my Doctoral Thesis. I selected electromagnetic pulse pressing of metal powders as my main research area. The theme was topical, very new, but at the same time difficult, as it was related to high voltage, short process duration, large impulse strength and fine materials. My colleagues Ojārs Dzenītis and Gunārs Grīnfelds also were Doctoral students. Their themes were also related to pulse magnetic processing of materials. I remember well our first business trip to Vyborg Shipyard. We discussed experiments on the application of pulsed electromagnetic fields for pipe pressing and demonstrated our achievements. At the same time, my first scientific publication in the journal "Mashinostroitel" was published. I need to say that our work was not safe, because the unit produced a discharge of capacitors with the voltage of 10–15 thous. volts, but the discharge current reached 20 thous. ampere. Forces were so strong that they destroyed steel casings of inductors, and their wiring turned into shot. We had to elaborate special precaution measures and reinforce inductor structures. Unfortunately, a year later, Gunārs Grīnfelds was expelled from the Doctoral studies. We were told that he had some relations with nationalists in Lithuania. It was really a pity. He greatly helped me to solve the problems related to measurement of pulse parameters.

For young scholars, attendance of the conferences and meetings with colleagues and established scientists were of great importance. It appeared that such top scientists as Landau and Knopfel, Winkler and Scheinberg were working on pulsed fields. We also got acquainted with young devotees, who worked on that theme: Khimenko, Gorkin, Mikhailov (Kharkov Polytechnic Institute), Vladimir Gluschenkov (Kuibishev Polytechnic Institute), Nikolay Nazarov (Minsk Polytechnic Institute) and many others.

My research theme was related both to electromagnetic impulses and powder metallurgy. Everything was new and interesting; the theme seemed to be very, very promising.

I managed to complete my Doctoral Thesis within three years mostly due to our contacts with Belorussian scholars. I learned from literature that scholars at Belorussian Polytechnic Institute in Minsk achieved the best results in the research of pulsed processes in powder metallurgy. I decided to go there and met Professor Oleg Roman. He agreed to be my second supervisor. But in fact he was the main one. Trips to Minsk, contacts, exchange of best practices contributed a lot to completion of the work. I successfully defended my thesis at Riga Polytechnic Institute at the Joint Council of Machine Building and Construction in 1972. I was awarded my first scientific degree – candidate of technical sciences. By that time, I had only a few scientific publications, but they were the first on the subject.

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3. Mironov, V., Pogodin, E. Технология изготовления идукторов для электромагнитной обработки. // Production Technology for Inductors for

Electromagnetic Treatment. In: Молодые ученые республики – народному хозяйству – RPI, Riga, 1970. – Part 1, pp. 73–75.

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10. Academic Training Abroad

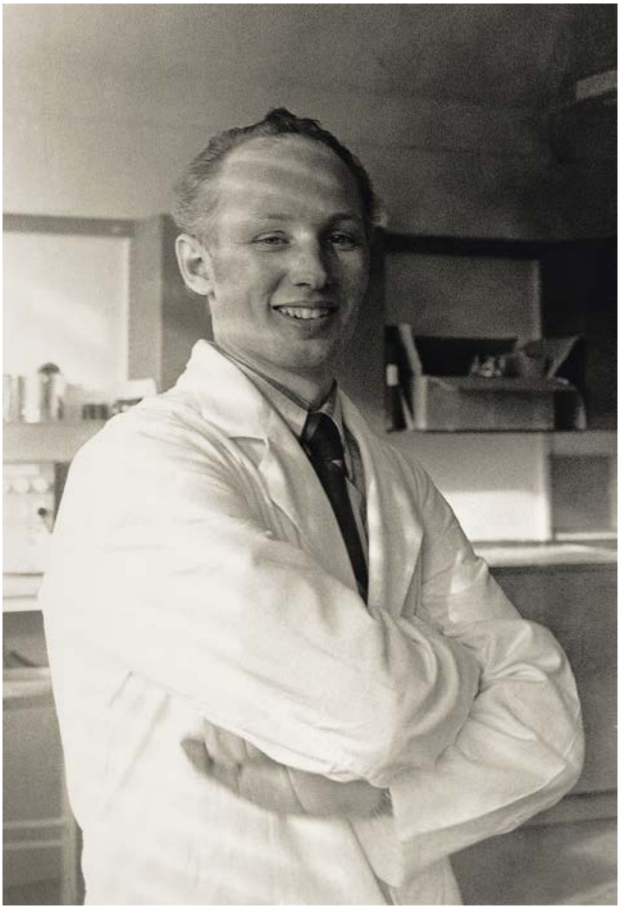
(Sweden, 1974–1975)

As I was a young specialist, in 1974 I was offered an opportunity to work at some university in Western Europe for a year. Following Prof. O. Roman’s advice, I chose Chalmers University of Technology in Gothenburg (Sweden). A renowned professor Hellmut Fischmeister agreed to be my supervisor; he was a scholar of German origin, who immigrated to Sweden during World War II. He was a wonderful person, well-known in the academic community, and a good manager. First it was very difficult for me, because, as I found out, I came to Sweden with a little knowledge of German. I had to learn English

Prof. Gerhard Bokstigel (left) and prof. Helmut Fishmeister (right), 1975.

spoken fluently by all staff members, and also to learn Swedish and work in a conceptually new academic environment. I received support and assistance on navigation in a new environment from the staff of the Institute of Materials Science, first of all from Professor Fischmeister and my tutor Geran Shoberg. We were working together on hot dynamic powder hammering. I learned about a new approach to tests. Primarily I was astonished with thorough preparation and scrupulous description of a future test, repeat testing, numerical test processing and analysis, comprehensive description covering all aspects, test reporting, which eventually resulted in writing an article in English for publication in a famous journal.

All major equipment of the Institute of Materials Science in Chalmers was located in a huge room. It could be used by all institute staff members. They just had to agree in advance on the time of test. Measurement and other special devices were temporarily rented from different companies. Their technical



Victor Mironov –
Head of the Scientific Lab
of Powder Materials and Pulsed
Processes, 1976.

support staff came to adjust the press, oscillograph, pyrometer, slow-motion camera and other systems.

We achieved good results and demonstrated opportunities of effective application of hot powder product hammering in production of toothed racks. The results were transferred to many companies in Sweden, South Korea and Japan according to the terms of the contract.

Another interesting work was related to the application of iron powder briquette infiltration with molten copper. Powder product was placed into a copper shell, and then it was heated with high-frequency currents to the melting point of copper. Afterwards, the results of that research found practical use in real manufacturing, including Riga Electric Machine Building Works (RER). During my work in Sweden I also gained my first experience in writing articles for international journals.

After my return from Sweden in 1976, the Institute Laboratory of Powder Materials and Pulse Technology was created at the Faculty of Civil Engineering with the support of Rector A. Vejs and Professor V. Dzenis.

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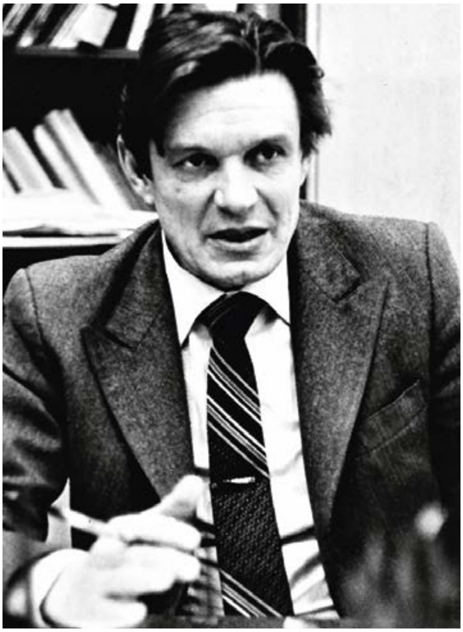
3. Sjoberg, G., Fischemeister, H., Mironov, V. Die Filling and Densification in Hot Extrusion Forging of Porous Preforms. Powder Metallurgy International. – 1977. – Vol. 9, N 4. – pp. 160–164. – Bibliog. : p. 164 (16 ref.).

11. Teaching Practice at RPI

Upon completion of the Doctoral studies and the viva of the Thesis in 1972 I received a job offer of a senior lecturer (Assistant Professor) at RPI Faculty of Civil Engineering. I started delivering lectures on the following subjects: “Machine Parts”, “Carrying and Lifting Machines”, and “General Course on Construction Machines”. In the beginning, I delivered lectures only at the Night Department, but in a year I could deliver them to all the students of the Faculty of Civil Engineering. My work experience from the shipyard provided good knowledge of design and functioning of most machines and other equipment, although I had to study on my own quite a lot, especially on the issues related to civil engineering technologies. The teaching staff of the Chair of Construction Works was very nice, young enough, and multinational. Work atmosphere was friendly. I need to extend huge thanks to Laimonis Bārzdiņš, Head of the Chair, to Voldemārs Dzenis, and to my colleagues Edvard Kurnosov, Galina Grom, Eižens Ziediņš and many others, who I worked with.

At the end of the 1980’s, the Chair had become the largest (about 50 people) at the Faculty, and perhaps the most efficient. Our scientific achievements also were really noteworthy. Professor Voldemārs Dzenis and his group worked actively on non-destructive control of materials, Associate Professor Edvard Kurnosov was one of the renowned Latvian scholars working on aerated concrete technologies, Professor Cimmermanis with his group carried out interesting research in the field of high-strength gypsum. Research activities of my group were related to

Associate Professor of Riga Polytechnic Institute Viktor Mironov, 1984.



Supervisor – Director of the Institute of Powder Metallurgy (Minsk), Professor Oleg Roman.

the development of hardening coating application methods to enhance reliability and performance of construction equipment. Each research group consisted of several Doctoral students and we involved many students in our research works. Normally research was performed under direct contracts with enterprises. No any special funding from the budget was allocated.

During those years (1975–1985), we also worked a lot on guidance support publishing lecture notes and methodological aids. For the first time in history, special training premises were set up at the Chair: "Heavy Construction Machines", "Automotive Vehicles", "Manual Power-Driven Bits and Tools" equipped with a lot of lab facilities and test models. Lab assistants, undergraduate and Doctoral students took active part in the works. They treated test models, painted and installed them. Students were taught in two languages – Latvian and Russian in parallel courses. By the way, we received many test models from VDNH pavilion in Moscow. Test models for automotive vehicle class were presented by the Military Chair of RPI. Different manual tools were provided by Rezekne Manufacture of Power-Driven Hand Tools as industry support.

After the restoration of independence of Latvia, Riga Polytechnic Institute was renamed Riga Technical University. I received the position of Professor at the Department of Construction Machines and Materials.

Group of graduate students. Curator - Associate Professor Viktor Mironov, 1982.

Student A. Bronka passes exam to Professor V. Mironov.

The team of the Construction Production Department of Riga Polytechnic Institute, 1988.

At the beginning of the 1990's the number of students reduced drastically. Many teachers left the University, lab assistants also were not employed anymore. Mainly the teaching staff approaching the retirement age remained at the Chair. Teaching process shifted to the Latvian language only. With great difficulty we could keep the major part of laboratory equipment, but it was getting out-of-date very fast. My group members, Gunta Antonova and Vasily Kolosov, were of great support to me. The number of students started growing gradually only after 2001.

In 1998, my diploma was nostrificated in Latvia and after elections I was appointed the Head of the Professor's Group "Construction Machines and Equipment". Active revival started about the year 2005. Already by 2008 I taught 10–12 groups of students (over 200 people at a time). They studied the mandatory general course "Construction Machines" and special courses. Over the past years, more than 4,000 students have attended my lectures. With true gratitude I should mention my teaching assistants Nikolay Kruglov and Gunta Antonova. Later on my Doctoral students Vyacheslav Lapkovsky, Mikhail Lisicin, and Jānis Baroniņš actively helped me in organization and implementation of laboratory works.

Preparation for laboratory studies with students within the course „Construction machines and mechanisms". Vasily Kolosov and Gunta Antonova.

My cooperation with the journal *Būvet* played a major role. I wrote articles on mechanization of construction processes in Russian, and a journal employee translated them into Latvian. This way, more than 30 articles were written, which afterwards became the basis for several text books and learning aids.

Unfortunately, by decision of the Faculty Council in 2014 the courses on construction machines and power-driven tools were categorized as electives. Now students could choose them voluntarily, but that happened rarely, perhaps because of rather high requirements and a large scope of laboratory and practical works. The number of students attending lectures decreased to 10–15 people. My experience was yet helpful in supervision of Bachelor and Master Theses.

Due to the reconstruction and repair works in the building of the Faculty of Civil Engineering in 2016 all premises for the practical classes mentioned above were closed, and the equipment was handled to technical museums and scrap deposits. À propos, when I visit Tartu University Institute of Technology, I always get surprised by the number of exhibits, even from the 1960's and earlier times, which are kept, maintained and ready for use. They are installed on special movable racks and have name plates in several languages.

In 2012, I started delivering lectures at RTU Faculty of Mechanical Engineering, Transport and Aeronautics, particularly, at the Chair of Air Transport ("Mechanization of Transportation", "Machines and Mechanisms of Stream-Flow Transportation", etc.).

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10. Mironov, V., Puzirev, N., Kochakyan, S. Механизация строительных процессов. // Automation of Construction Processes. ТвГТУ, Tver, Russia, 2011, 288 p.

12. Working with Students in the New Environment

Since the late 1970's onward the teaching process at RTU has changed considerably. Latvia joined to the Bologna Process in the field of education. The goal was to reconcile the levels of higher education in all European countries and make the awarded degrees easily comparable. Such unification should have promoted international scientific exchange. Within the new system, "Bachelor" and "Master" degrees are considered to be scientific degrees.

Since 1994, we also have been educating and training Bachelors and Masters. We did not have any experience, so in the beginning we used the old methodologies, but the number of contact hours with students was decreasing drastically. If in the 1980's the volume of the course "Construction Machines" was 350 contact hours, then in 2000 it was only 75. Although a few years later one extra year was added to Bachelor and engineer degree programs, and 2 kinds of diplomas were awarded: Bachelor's and diploma in engineering. Since the early 2000's I have to pay much attention to working with students both as a supervisor of their Bachelor and Master Theses and as a reviewer of such papers.

Autonomous student work has been ascribed special weight in education – writing of the term papers and reports, as well as development of Bachelor and Master Papers. In this case, the role of research laboratories where the students can do research on the selected theme has increased. The titles of some papers developed to obtain Bachelor or Master Degree under my supervision are listed below.

International students started enrolling in RTU. I also had to improve my knowledge of English and take a group for studies consisting of the students from India, Pakistan, and Algeria. However, this experience was not too successful. The students were mainly poorly prepared and we did not have sufficient materials, experience and equipment for such a work. It was a lot more interesting to work with interns from other countries, as they came to stay for several months or even for one year to perform scientific work within various projects, such as Erasmus, for instance. I managed to establish good creative relations with some of them, for example, with Julia Usherenko from Minsk, or with Irina Belyayeva from Samara.

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3. Toufic Abou Merhi "Pile Works in Constructions", Bachelor Paper, 2001.
4. Aļoškins, Iļja. "Mini ekskavatori un to pielietošana"(Mini-Excavators and their Application), Bachelor Paper, 2002.
5. Pielēns, Kaspars. "Mūsdienu vienkausa ekskavators un tā pielietojums" (Application of Modern Single-Bucket Excavators), Bachelor Paper, 2002.

6. Tarkovs, Dmitrijs. Zemes darbu kompaktmašīnas (Compaction Machines in Earthworks), Bachelor Paper, 2003.
7. Rokina, Nataļja. Lokanās vilkmes ventilācijas sistēmas. Izvēle. Montāža. Izmantošana (Flexible Ventilation Systems. Selection, Installation, Applications), Bachelor Paper, 2003.
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13. Work with Post-Graduate and Doctoral Students

Training of scientific personnel is one of the most significant results of teaching and research practice. Dissertations of my post-graduate students (Doctoral students) were related to research work conducted at the laboratory. The research themes mainly were developed in the domains of processing of materials in pulsed electromagnetic field and powder metallurgy. The developed dissertations were presented for viva in Riga, Minsk and Moscow. Work with young candidates for a scientific degree was very interesting, although labor-intensive. They are like children – they need much care, but you learn much new and do not get old.

Meeting with the first graduate student, now a Doctor of Engineering Sciences
Vyacheslav Zemchenkov, 2014.

Vyacheslav Zemchenkov was my first postgraduate student. He defended his dissertation in 1985. Later I supervised the works of Vadim Sokolov (1987), Igor Molochkov (1988) and Anatoly Kot (1989).

In the 1990's postgraduate studies in Latvia lost their prestige. Many of our postgraduate students quitted their themes and left the institute. Those included Victor Zhuravlyov, Roberts Spunde, Youry Maksimov, Galina Grom. Some students could not finalize their dissertations because of the collapse of the USSR and "perestroika". It is a great pity that my Doctoral students Pavel Levin, Vitaly Verhovsky, Galina Tarasova, Inessa Trushinya and others quitted their studies… Some of them started their own businesses; some of them left the country.

A new positive trend started in 2005. During my trip to Munich, where I was taking a course on patenting, I met Vyacheslav Lapkovskis. He became my Doctoral student. Although he worked on his dissertation for rather long time, he successfully completed it and took the viva in 2012. In that very period a new generation of future scientists joined the laboratory staff, some of them have already defended their dissertations and others are preparing them for defense. Those include Irina Boiko, Andrey Shishkin, Michail Lisicin, Jānis Baroniņš,

10 years of collaboration at the Laboratory of Powder Materials (Victor Mironov, Mikhail Lisitsyn, Jānis Baroniņš, Irina Boyko, Vyacheslav Lapkovsky, Andrey Shishkin).

Pavel Stankevich, Elīna Barone, and other. I want to mention a successful experience with adaptation and viva of the research paper by Irina Belyaeva, a researcher from Samara State Aerospace University.

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2. Mironov, V. Magnetic Pulsed Compaction and its Applications in Technological Processes: Summary of the dissertation for obtaining degree of Doctor of technical sciences. Sc. supervisor: Prof. Roman O. V. – Moscow. Institute of Fine Chemical Technologies, 1986. – 33 p. – Bibliog. : p. 33 (ref.).
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5. Sokolov, V. Sintered Pyroceramics Obtained from Glass Powders Using the Method of Centrifugal Molding. Dissertation of the candidate of technical sciences. Sc. supervisors: Mironov V. A., Bolshiy J. J. – Riga, RPI, 1987. – 161 p. – Bibliog. : pp. 144–162 (165 ref.).
6. Kot, A. Application and Treatment of Powder Coatings in Pulsed Electromagnetic Field. Summary of the dissertation for obtaining degree of the candidate of technical sciences. Sc. supervisors: Dorozhkin N. N., Mironov V. A. – Minsk, ИНДМаш, 1986. – 33 p. – Bibliog. : p. 32 (70 ref.).
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9. Treijs, J. Ferromagnetic Sorbents and their Potential for Collecting Pollution with Spilled Oil Products. Sc. supervisors V. Mironovs, E. Teirumnieks, RTU, 2018;
10. Stankevičs, P. Improvement of the Properties and Development of Production Technology of Antifriction Powder Parts Based on Fe-C-Cu Break Sections of the Rolling Stock. Sc. supervisor V. Mironovs, RTU, 2018 (preliminary viva);
11. Barone, E. High Hardness Non-oxide Materials from Ceramics Residues. Sc. supervisor V. Mironovs. RTU, 2016 (preliminary viva)
12. Lisicins, M. Determining the Properties of Perforated Steel Wastes and their Rational Use in Civil Engineering. Sc. supervisor V. Mironovs. RTU, 2018 (preliminary viva);
13. Šiškins, A. Development and Study of the Multifunctional Clay-Cullet Porous Materials. Sc. supervisors J. Ozolinš, V. Mironovs. RTU, 2018 (preliminary viva).

14. Work in the Field of Technical Terminology

The role of technical terminology is highly significant both in scientific research and in teaching, especially in different languages. At the end of the 1970's the RPI Chair of Construction Operations started working on elaboration of multilingual illustrated dictionary of terminology in construction machinery.

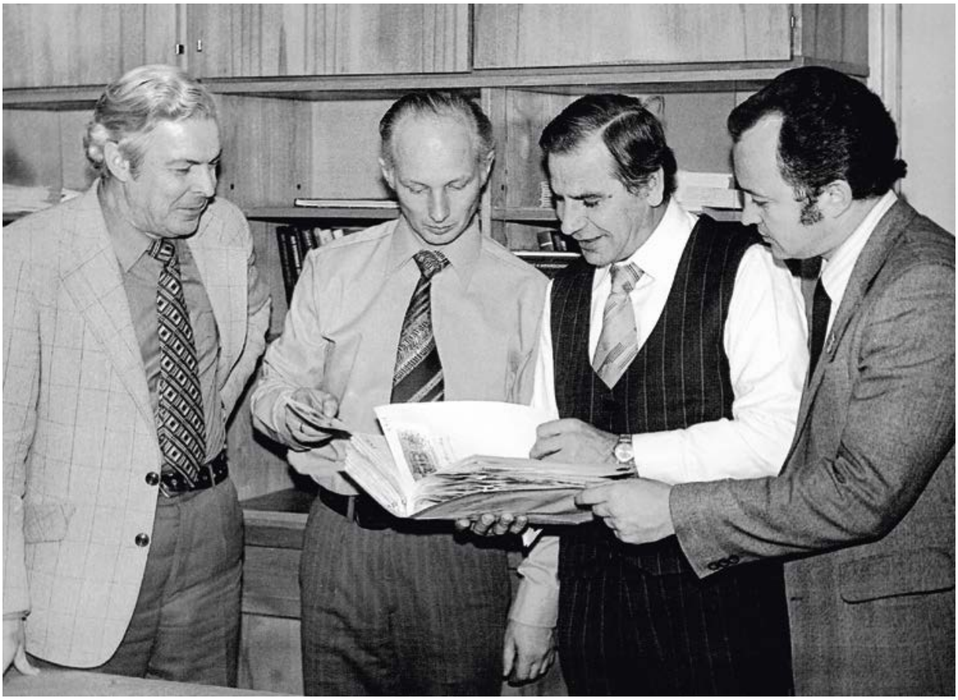
Technical multilingual dictionaries, compiled and edited by V. Mironov.

The idea belonged to Professor Gerhard Hake from Hochschule Wismar (Germany). During his visit to Riga in 1978, the cooperation agreement between RPI and Hochschule Wismar was signed. One of the clauses in the agreement envisioned elaboration of an illustrated dictionary of terms in construction machinery in four languages. It was an interesting work. It was a non-profit activity, as it was typical for those times, but it provided an opportunity to exchange opinions and methods of teaching, to arrange annual meetings with colleagues-specialists from different countries, to have discussions on common themes, and just to be friends.

As the result, by the end of the 1980's we issued a 4-volume illustrated dictionary, published in Riga and in Wismar (Germany). All the captions under illustrations were in German, Latvian, English and Russian.

In the 2000's, the idea of publishing an illustrated technical dictionary was supported by the Laboratory, which found its application in a range of publications on welding, construction machinery, and powder metallurgy equipment. Martiņš Zageris, Ināra Iesalniece, Andrey Shishkin, Vyacheslav Lapkovskis and many, many other students took active part in this work.

- Illustrated Dictionary of Construction Machines //Bildwörterbuch Baumaschinen. Hake, G., Mironov V. A. et al. – Wismar, 1983. – vol. 1. – 198 p. : ill.



Work on the compilation of an illustrated dictionary. Associate Professor Eigen Ziedins (left), Prof. Helmut Hake and Associate Professor Georgy Boldyrev (right), 1978.

- Illustrated Dictionary of Construction Machines. Hake, G., Mironov V. A. et al. – Riga: RPI, 1985. – vol. 2: Carrying and Lifting Machines. – 159 p.
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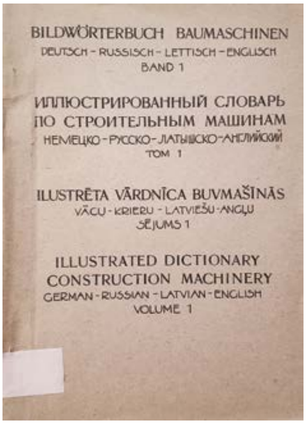
Tutorials and Dictionaries (Glossaries)

Professional training of technical specialists necessarily requires a wide use of special literature, catalogs of companies, publications in technical journals and on the websites of leading world companies. The study and use of these materials is impossible without technical terminological dictionaries (glossaries), textbooks and tutorials.

From 1975 to 2010, the author has developed more than 40 different textbooks, lecture courses, illustrated dictionaries of technical terms (glossaries) in the field of materials science, mechanical engineering, welding, construction machinery and construction mechanization. Each term there has an illustration, which is accompanied by a caption in four languages: Russian, Latvian, German and English.



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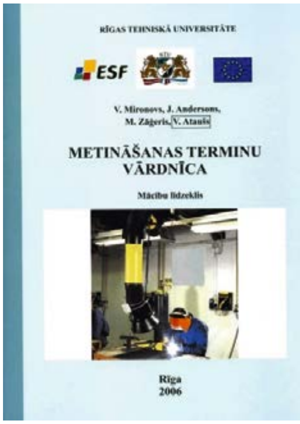

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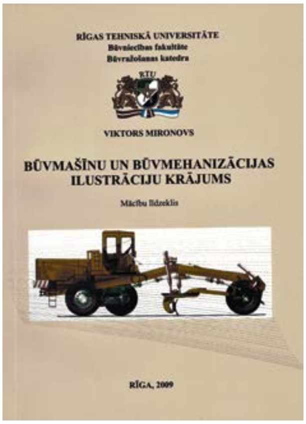


2009

2009

15. Development of Pulsed Electromagnetic Field Technologies

15.1. Magnetic Pulse Pressing of Powders

The first publications on the application of pulsed electromagnetic fields (PEF) for pressing of powder materials appeared at the beginning of the 1970's. The idea was to fill the tubular copper or aluminum case and insert it into a multiturn coil-inductor. When the inductor was supplied with a strong pulsating current from the pre-charged capacitors, electromagnetic field was generated for a few micro- or nanoseconds. Significant electrodynamic forces appear as the result of interaction between the field inside the inductor and induced currents in the electrically conducting case. An opportunity to obtain large specific pressures, high speed of the process and direct impact of electromagnetic field upon a material – all these factors attracted attention of scientists and manufacturers in many countries of the world, especially in the USA, Germany, Russia, and Japan.

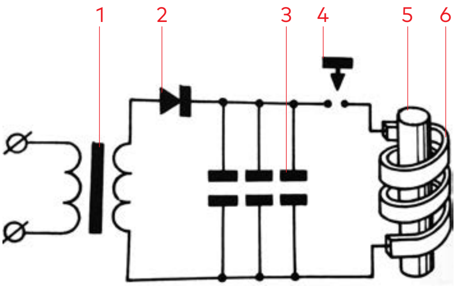
I received an invitation to work on the applied technology of pulsed electromagnetic fields from Ēriks Jankops, an assistant professor of the RPI Chair of General Electrical Engineering. He used the capacitor dump to make locks at continuous casting of metals. While working on that project, it turned out that electromagnetic field can be effectively used for powder fill thin-wall metal pipe pressing. The novelty of the process was indisputable. Still those technologies appeared to be too complicated to get commercialized fast. Mastering of the method took many years. Many scientific publications, monographs, patents, promotion materials were published, laboratory and industrial pilot units were designed and studied during that period.

Having thoroughly considered and consulted with specialists from Riga and Minsk, I still made a decision to orient my research activities at powder metallurgy, i. e. at the application of the electromagnetic field for powder pressing and powder coating methods.

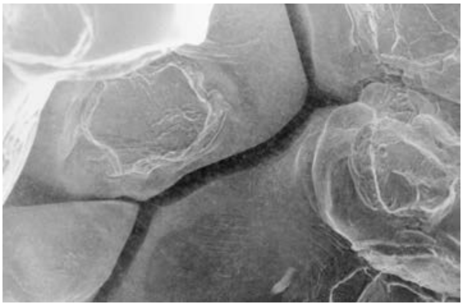
More than 40 years were dedicated to the research of these processes. Finally I defended the candidate dissertation at Riga Polytechnic Institute (1972), and later on – the Doctoral Thesis at Lomonosov Moscow State University of Fine Chemical Technologies (1986). The research results were also reflected in two monographs and in a few dozens of research articles.

Magnetic pulsed pressing of powders (MPPP)

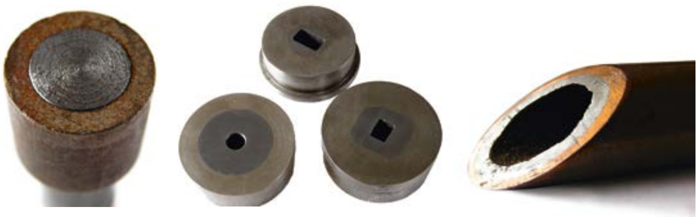
The fundamentals of the theory of powder pressing, compaction and deformation of powder samples by a pulsed electromagnetic field have been developed. The laws of the interaction of the electromagnetic field with the electrically conducting surface have been established, and recommendations have been formulated for a reasonable choice of parameters of equipment and tools. Technological processes of pressing, consolidation, local deformation, assembly of powder parts and of powder coatings' applications have been developed.



MPPP schematic presentation:
1 – step-up transformer;
2 – rectifier;
3 – power accumulator;
4 – discharger;
5 – powder sample;
6 – inductor (coil).



Powder-like bronze before and after processing by a pulsed electromagnetic field.



Application of the MPPP method for manufacturing filters.

Technology for manufacturing multilayer parts from metallic and non-metallic materials (steel-bronze, copper-steel, Fe-Cu –WC-Co solid alloy).

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15.2. Research on Infiltration of Materials with Metal Melts

The process of infiltration powder blanks with metal melts is one of the most efficient PM technological operations. It allows increasing the density of the resulting parts, obtaining materials with new properties, it also offers other advantages. This method started to get actively used in the 1960-70's. Its essence consists in the saturation of the powder material with a more easily fusible metal heating it to its melting point.

For a long time, the use of copper coil was a serious limitation for the application of the method of magnetic pulse pressing of powders. Melting of the coil material during sintering and infiltration allowed improving the properties of the product and simultaneously getting rid of the coil. We obtained one of our first inventor certificates for this method. The story how we discovered this effect is really interesting. Once I handed over the blanks in copper coil treated with magnetic pulse to the laboratory for sintering and asked the laboratory staff to sinter them at 900 degrees C. But the lab assistant made a mistake – she performed the sintering at 1,000 degrees C. The samples were obviously spoiled. We were considering disposing of the samples, but still decided to analyze their structure. It turned out that the density of the samples was almost 100%.

The method started developing fast. At the end of the 1990's, more than 400 tons of produce made using the method of infiltration of foaming iron-copper blanks with copper was manufactured at the Powder Metallurgy Plant in Riga. These were the elements of centrifugal flow pumps for pumping petroleum products. Unfortunately, in 2004 the owners sold the plant to a foreign company, the equipment was moved from the territory of Latvia in 2007.

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15.3. Current Pulse Generators

We had a positive experience in the design of devices for pressing pipes and compacting powders using current pulse generators (CPG). Already in 1972 we made the first pilot-plant equipment for the Shipyard in Vyborg, later we supplied some plants to Kazan and Moscow. These were pilot-plant CPGs with the relatively high energy content ranging from 10 to 40 kJ. Major role was played by the cooperation with the leading organizations in this area – TsNIIMash (Leningrad), KAI (Kuybyshev), KhPI (Kharkov) and other institutions.

After "perestroika", our laboratory did not anymore have technical capacity for the development and design of such CPGs, thus we decided to move to the area of low energies.

We actively discussed the design of small-scale CPGs already at the beginning of the 1980's. Riga Polytechnic Institute received a request from Prof. Deglavs from Riga Institute of Traumatology and Orthopedics for the development of the method and a magnetic pulse device for diagnostics and treatment of diseases. A small-scale CPG that we designed was not yet suitable for real application in medicine, numerous certifications and approvals had to be received. The designed generators had the operating voltage of not higher than 1,000 V, therefore they could be used in the laboratory conditions. We successfully used these devices for the demonstration of magnetic pulse processes: transportation of metal plates, jarring and movement of powder materials, peeling of conductive coatings. They were demonstrated at many exhibitions in Riga, Moscow, and Minsk. A member of our staff Vasily Kolosov made a considerable contribution to creation of original solutions. We transferred one of the CPGs to the Swedish company Höganäs AB under the terms of the agreements and it was on display at the company for several years.

In recent years, design of small-scale CPGs has become particularly topical. Such devices are of great use in solving many tasks in instrument manufacturing, for example, pulse dosage meters, high-speed circuit breakers and other equipment. Such magnetic pulse devices may be used to demonstrate the effect of the impact of pulsed electromagnetic field on the behavior of ferromagnetic materials in different environments, for instance, by means of their accelerated transportation. Devices of this kind may be actively used for education purposes.

At present, the main area of interest is the research on the combined process of material deformation and powder pressing. In this case, an impulse source (CPG) is used for preliminary pressing of the blank, and the deformation as such is performed by drawing or die forging.

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15.4. Modeling

Prediction of the properties of materials and coatings, selection of processing modes and other issues may be successfully solved using the methods of mathematical modeling. We developed theoretical models of magnetic pulse pressing of powders in cooperation with the staff of Kharkov Polytechnic Institute (Prof. V. Mikhailov). V. Eglājs, V. Gemsts, A. Actiņš and other took part in the research on the part of Riga Polytechnic Institute.

In recent years, we have studied the processes of powder transportation in the pulsed electromagnetic field using modern software. Prof. Jānis Viba and a Doctoral student Vyacheslav Lapkovskis took part in this research.

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15.5. Intensification of Technological Processes of Production and Transportation of Bulk Materials with Pulsed Electromagnetic Field

Development of the methods for process intensification during production and transportation of the cargo is an important task. The main area of their application is advancement of efficiency of unloading of powder materials from containers, carriages, road transport and other compartments. Our initial research conducted in the 1990's demonstrated the opportunities for efficient use of electromagnetic impulses for speeding up materials unloading. Laboratory equipment for the demonstration of the process of impulse jarring of the compacted powders was developed. Several attempts to use the systems of electromagnetic jarring of consolidated bulk materials on the basis of the custom designed devices in the real operating conditions were made.

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15.6. Transportation of Materials in Pulsed Electromagnetic Field

At the beginning of the 1970's, we discovered that during magnetic pulse treatment, parts are pushed out form the cylindrical coil. This phenomenon occurred if symmetric positioning of the material relative to the middle of the coil was compromised. In 1996, the member of our laboratory staff Vasily Kolosov suggested employing such axial deflection of the part. This is how the idea of electromagnetic elevator emerged. Using the lab device, we managed to transport various discrete steel and copper parts, as well as iron powders up to 1 kg of weight to the height of up to 3 meters.

The process appeared to be interesting from both theoretical and practical perspective. Prof. Jānis Viba, Irina Boyko and other RTU specialists took active part in further work. In 2012, at RTU Institute of Aeronautics under my supervision Vyacheslav Lapkovskis presented his Doctoral Thesis on this theme, and under the agreement with Höganäs AB (Sweden) a display model of the device for vertical transportation of the powders was designed. Research is this area continues. Impulse devices for movement of metal plates, hollow spheres and even non-metallic materials have been designed.

Movement of powder materials in the pulsed electromagnetic field (Electromagnetic elevator)

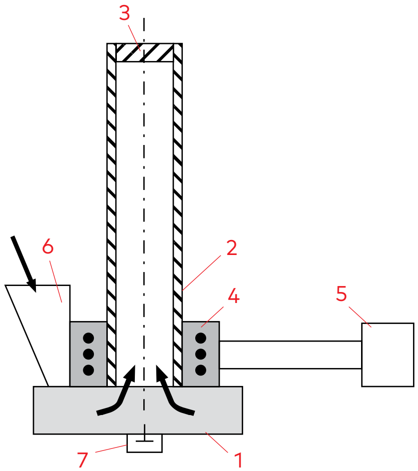

Fig. 1. Schematic presentation of the electromagnetic elevator: 1 – container with powder; 2 – pipe; 3 – plug; 4 – inductor; 5 – pulse current generator; 6 – powder supply.

Fig. 2. Small-size generator of pulse currents for processing powder materials.

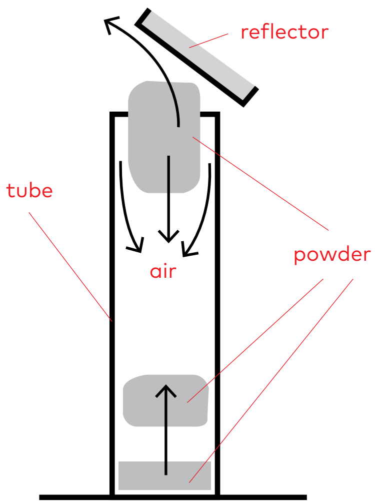

Fig. 3. Investigation of arching processes when powders are supplied from a tank and then destroyed by the pulsed magnetic field. 1 – powder; 2 – tank wall; 3 – inductor; 4 - pulse current generator.

Fig. 4. Experimental device for moving ferromagnetic powders by the pulsed electromagnetic field, providing lifting of about 1 kg of powder as high as 3 m.

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15.7. Assembly Operations Using Electromagnetic Forces

Magnetic pulse pressing of powder products turned out to be very efficient in conducting assembly works in machine and tool engineering, for example, in joining pipes, pressing collars, installation of protective coats. We started our first experiments in this area while performing contractual work for the Shipyard in Vyborg at the beginning of the 1970's. The task consisted in joining copper pipes with steel pipes, as well as fitting of the end plugs. The contract was successfully implemented, but we did not manage to design an industrial-scale plant, because apart from the generator it was necessary to install a reliable and safe inductor. Within the terms of the contract, it was supposed to ensure more than 1,000 operating pulses at the frequency not less than 20 per hour. However, it should be kept in mind that the pressures of more than 300 MPa should be applied for the deformation of the copper pipe 40–50 mm in diameter with wall thickness of 3–4 mm. This, however, could be reached at pulsed discharge of about 20 kJ. In this case, short-term impulse current of 30 kA and voltage not less than 10 kV went through the inductor coil. These conditions are anything but rough. While testing the process in laboratory conditions, such faults as insulation failures, mechanical destruction of the leads, and coil overheating occurred. As the result, the inductors did not sustain more than 50 impulses.

Our colleagues from Germany (Prof. Harry Wolf, Günter Pfretzschner from Zwickau) solved this task at the expense of decrease of energy efficiency. They performed operation of this kind on the 50 kJ power plant. At present, the best practical results in the area of pressing and assembly of tubular parts have been obtained by our colleagues form Dortmund (Germany). In recent years, in cooperation with West Saxon University of Applied Sciences Zwickau (Prof. Matthias Kolbe) we have obtained interesting results in deformation and assembly of sintered powdered metal parts.

Metal elastic deformation and assembling of parts in the pulsed electromagnetic field

The project is aimed at the development of technologies of magnetic pulsed deformation of tubular pieces and at the production of permanent joints of elements made of different metallic materials. Numerous samples of pipe (made of aluminium, copper, and steel) connections, compressed fibrous materials and wires have been manufactured.

Fig. 1. Assembly of tubular parts by compressing in an electromagnetic field.

Fig. 2. A detail with high permeability.

Fig. 3. Wire compressing in a tube.

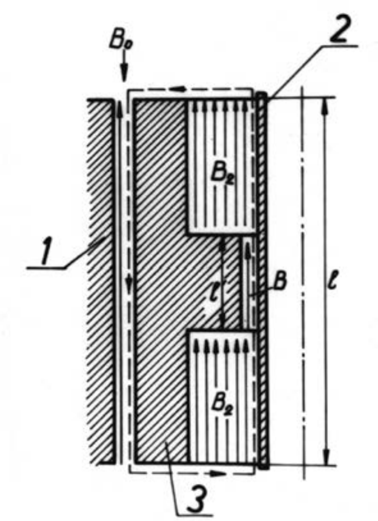

Fig. 4. Electromagnetic field concentrator and its application in detail assembling.

Fig. 5. Flat electromagnetic punching.

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16. Powder Metallurgy

16.1. Trend Analysis

My first encounter with powder metallurgy (PM) occurred in 1968 during my visit to special PM engineering design bureau at Riga Electric Machine Building Works (RER). The bureau was headed by Alexander Godes. He wrote a brochure

At the exhibition stand of the company Höganäs, 2002.

about the state-of-the-art and the opportunities offered by the new technology of powder metallurgy based on the proceedings of the recent international conference organized in Austria. This field of research fascinated me with the huge opportunities it opened, both in terms of the newest scientific achievements and practical application of an entirely new manufacturing method. It seemed to be fully automated, non-waste and highly efficient. At presents, such PM plants have been established in many countries, for example, company MIBA with branches in Slovakia and Argentina.

In the 1980's, Latvia became a noticeable player in the field of PM. This was promoted by achievements of Riga Electric Machine Building Works in machine part production. An experienced team of researchers was established under the leadership of Alexander Godes. Some divisions were headed by Nicolay Sugok and Milita Krūmiņa. They successfully solved the tasks related to the launch of manufacturing of powder details in batch and mass production.

At the end of the 1980's, a new Experimental Powder Metallurgy Plant (EPMP) was designed and constructed with capacity of up to 2,500 tons of articles per year. The workshops on production of silver-based electric contacts and a range of details from iron-copper composites were particularly efficient.

Active research on PM commenced also at Riga Polytechnic Institute. A research laboratory of powder materials was established, and the main facilities

Meeting with Sonata Johanson, Höganäs, 2013.

of the laboratory were located in EPMP territory. Such researchers as Vyacheslav Zemchenkov, Ivan Petrov, Vadim Ackermann, and Igor Molochkov developed and successfully presented their candidate dissertations at this laboratory under my supervision. Regional and international conferences in powder metallurgy started to get organized in Riga.

In the USSR there was a considerable interest in PM. The total powder manufacturing volume in the country had been growing rapidly. By the end of 1980's it reached 50 thous. tons a year. At the same time, import constituted only 400–500 tons annually. New manufacturing facilities for production of iron powders were established – the plant "Red Sulin" was built next to Rostov-on-Don, Brovarsk Powder Metallurgy Plant in Ukraine, large works at Cherepovets Metallurgical Plant were founded. The largest plant in Europe for production of copper powder was launched in Sverdlovsk Oblast, the Zaporozhye Titanium-Magnesium Combine and other plants were founded.

Association of Powder Metallurgy in Minsk headed by my scientific supervisor Oleg Roman became one of the centers of research and manufacturing in the USSR. O. Roman also was the Chairman of the Coordination Scientific Council on Powder Metallurgy in Minsk. I represented Latvia in this Council. At the meetings of the Council, the main achievements in the PM research and technologies were considered, as well as the main tendencies in PM development

During the cruise in honor of the 200th anniversary of Höganäs Company, 1997.

in the world. There I met Academician Antsiferov (Perm), Professor Priit Kulu (Tallinn), Skorohod (Kiev) and many other prominent specialists in PM. At the meetings, I reported on the development of this industry in Latvia and took part in the discussions on the main trends in PM.

In the 1990's, the situation in the area of PM in the post-Soviet space changed radically. It was connected with the closure of many plants and factories dealing with production of powders and articles made form powders, increase of export of materials, decrease of the prestige of the industry, and the fact that highly qualified staff kept leaving the industry.

During these very complicated and harsh years, very important and largely positive role was played by the policies and active work of the Swedish company Höganäs in Russia. I started cooperating with this company in 2003. This allowed sustaining and even promoting the contacts among the specialists of the remaining PM enterprises. Annual seminars, free supply of powder samples, informative support materials, the Summer School Höganäs-PM established in

Meeting with the Presidents of the European Powder Metallurgy Association.

the territory of Russia and Sweden promoted trust and increased demand for the powders supplied by the company.

In the course of my cooperation with the company Höganäs AB, my active interest in the research on the dynamics and the global development trends in Powder Metallurgy continued. It should be noted that Höganäs AB is the world largest producer of iron and steel powders. It produces more than 1 m tons of different powder materials annually. My research connections, experience and knowledge in the area of PM, involvement in the development of the industry Russia, other NIS countries and the Baltics were of considerable interest for the company in 1994–2004. My activities related to organizing numerous business meetings at the enterprises, setting up of stands at the exhibitions, organization of visits of the specialists to Sweden to the company plants and, finally, establishment of Höganäs School of Powder Metallurgy in Russia were among the factors that promoted the company performance in this market resulting in the fact that already in 2005 the total volume of supply of powders from Sweden reached 15,000 tons per year. In 2011, a subsidiary company Höganäs Osteuropa was founded in St. Petersburg.

Powder Metallurgy Association (President Youry Korolyov) was established in Russia already in 1995. However, its activity used to be and remains rather unnoticed. Such regional centers are a lot more well-known: the Institute of Powder Metallurgy (Minsk, Belarus), the Institute for Problems in Materials

Meeting with colleagues at the conference. Lansoo (Tallinn TU) and Bochkus (Kaunas TU.Tallinn 2006).

Science (Kiev, Ukraine), and Perm State Technical University (Perm, Russia). They organize specialized conferences in powder and nanomaterials in their countries, publish materials on their achievements. It should be noted though that the number of researchers and specialists from Russia, Ukraine and Belarus at the large international PM conferences dropped radically in the 1990's, even now these numbers are not high.

In Europe, public activity in PM is coordinated by the European Powder Metallurgy Association (EPMA), which regularly organizes conferences and PM schools, round tables and seminars.

In the Baltic countries, PM industry has not sustained. However, some research potential in this area has still remained in Tallinn University of Technology and Riga Technical University.

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16.2. Centrifugal Casting of Powders

The idea to use centrifugal forces for pressing powder materials emerged during my visit to the testing facility of Riga Electric Machine Building Works. High-speed centrifuge machines were used at the Works for testing the rotors of electric machines. We developed a centrifuge appliance for the casting of ceramic and metal powders, whose rotor turns at the speed of 6,000 rotations per minute. The research has shown great opportunities offered by this method: articles may be produces in a wide range of shapes given relatively simple production tooling, regulation and control of centrifugal forces made be done in a broad range, there is an opportunity to use heating, etc. This method proved to be most efficient in production of articles from ceramic mixtures. It is one of the types of slip casting. The results of this research are reflected in the thesis of one of my Doctoral students, at present a candidate of technical sciences Vadim Sokolov (Ackermann).

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16.3. Research on Hardmetal Powder Materials

Our research on hardmetal materials was also connected with the method of their magnetic pulse compaction. Tungsten and cobalt carbide powders were mixed with the plasticizer, placed in a thin copper skin and compacted using electromagnetic pulses. This allowed obtaining details with complex design, increasing material density. The research concerned the substantiation of the selection of compaction and sintering modes, properties and microstructure of the materials, economic efficiency of the method. The main research areas include design of equipment for powder metallurgy, die forging, electrospark treatment and other technologies.

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17. Experiments in Welding

I first got acquainted with the research on welding during my work at RPI Laboratory of Welding Process Automation in 1972, where I was sent upon completion of my Doctoral studies. Such highly experienced specialists as Bruno Rudzītis, Victor Ataush, and Eduard Moskvin worked there. The research concerned micro-welding of thin conductors. Experience gained was later used in the development of some new welding methods employing pulsed power sources for stud and pipe welding.

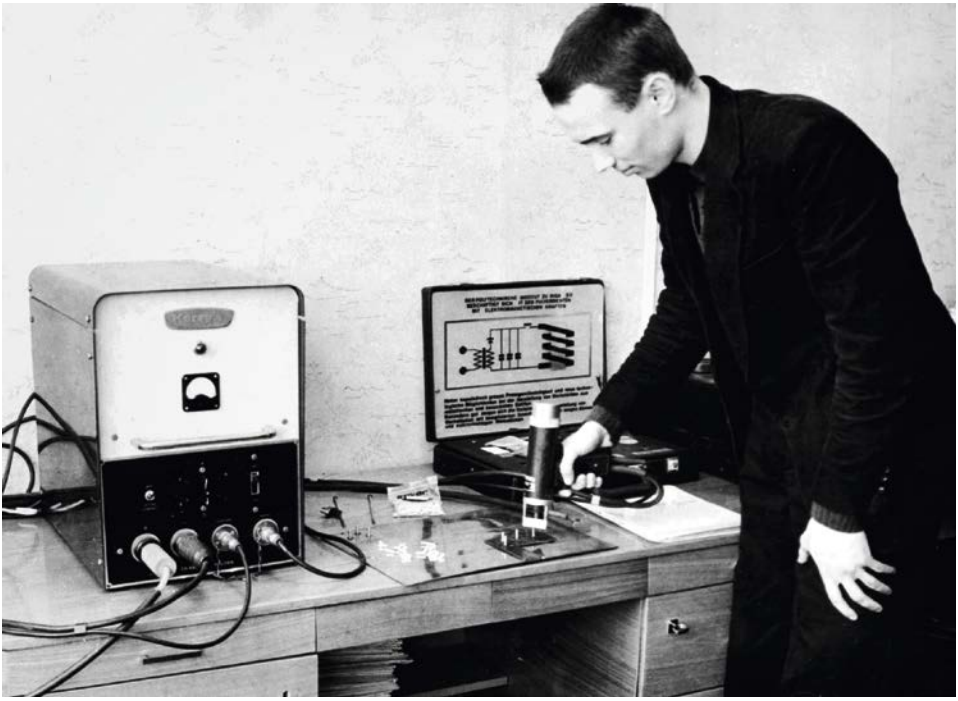
Since 1992, I started to get actively involved in the research into welding processes. It was connected with my work at the company ELKO Ltd and cooperation with the Laboratory of Welding of Riga Carriage Building Works.

Prof. Victor Mironov, Gunārs Cīrulis (ELKO Valmiera) and Klaus Schmidt (Oerlikon), Zurich, Switzerland, 1996.

At that time, under the leadership of the Director of the Works Jānis Andersons the Latvian Association of Welding Specialists was established. The Association invested a lot of effort in organizing exhibitions of welding equipment in Riga, inviting the leading companies to Latvia, it also organized training of the Latvian welding engineers with international qualification.

In the period from 1993 to 2000, active cooperation with such companies as ESAB (Sweden), OERLICON (Switzerland), Serpantinas Ltd, and ELKO Ltd (Latvia) was maintained through the Latvian Association of Welding Specialists. I organized several visits of the managers of the leading enterprises dealing with the manufacturing of welding materials from Russia and Latvia to Sweden and Switzerland. We established business and friendly relations with Mr. Frauenfelder (OERLICON), Thomas Luckmeier (Höganäs AB), and Gunārs Cīrulis (ELKO Ltd). At Riga Technical University, we conducted research in the field of electrode and energy pulse welding, pulse stud welding, application of metal powders for production of welding electrodes. Such colleagues as Levan Gabarashvili and Irina Boyko took active part in this research.

I gained considerable experience during my work at ELKO Ltd Valmiera in the period from 1994 to 1999. This company was established on the basis of the welding electrode workshop. The first task was to organize selling of the



Analysis of pulse stud welding process.

electrodes, because the traditional market had collapsed. It was necessary to look for new customers both in Latvia and abroad. We soon realized that manufacturing of electrodes was not competitive due to low quality and high costs. Therefore, we signed agreements with the companies ESAB and OERLICON on supply of welding materials and various equipment. It was necessary to invest enormous amount of work in market development: to study the functioning of numerous welding plants and equipment for welding joint inspection, translate descriptions and manuals, organize equipment exhibitions, and learn about ordering and marketing of equipment and materials. Two shops were open – one in Valmiera and one in Riga, an office and repair workshop in Valmiera, and a counseling office at RTU. In 1994, we organized the first international conference MET-94 (Welding and Powder Metallurgy).

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18. Development of New Composite Materials

18.1. Al-W-B Materials

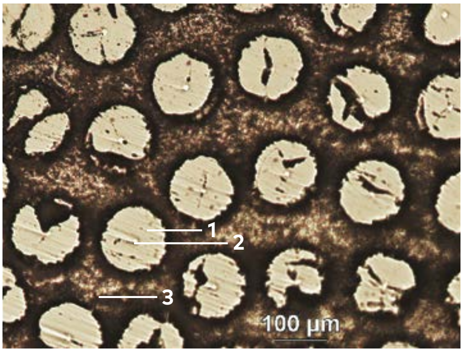
At the end of the 1980's, we started active cooperation with several leading organizations in Moscow (Institute of Metallurgy, CB Salut), Leningrad (TsNIIMash), Kazan, Minsk (Institute of Powder Metallurgy) and other centers working in the field of compacting, assembly and milling. Such specialists of the Institute of Physics of the Latvian Academy of Sciences as Faina Muktupāvela, J. Manika and other took part in this research.

Using the reserves of fibrous material wolfram (tungsten)–aluminum–boron stockpiled in Russia in the form of technological waste, for many years we implemented activities aimed at milling, rolling and sintering of these materials. Experimental work was performed at Riga Technical University and Tallinn University of Technology. Research in this area was also conducted at the Institute of Physics of the Latvian Academy of Sciences, Linköping University (Sweden), and A. A. Baikov Institute of Metallurgy and Materials Science (Moscow). We obtained the so-called "fibrous powders" characterized by high hardness and abrasiveness, as well as new composite materials based on them.

Investigation of properties and development of technologies for recycling composite material waste

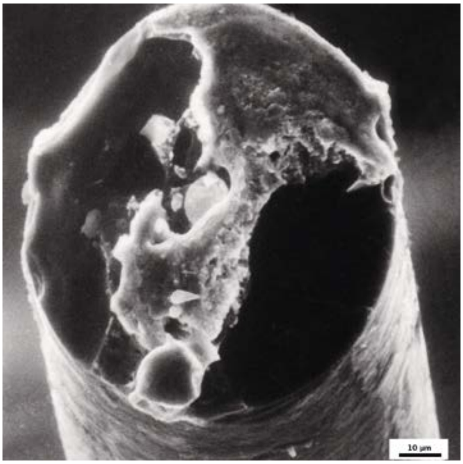
A composite material (CM) containing boron-tungsten fibers and an aluminum matrix (Al-W-B) was investigated. To process industrial waste, a method of grinding in the disintegrator was applied. The waste was grinded in a few steps to produce powders with a given particle size. The morphology of the particles and the dynamics of the grinding process were studied. Dependences of the energy consumption on the size of material grinding have been found. Data on the composite micro-hardness, on the friction and wear parameters were obtained. It was shown that the composite powders (Al-W-B) can be used in metallurgy as alloying additions as well as in manufacturing of tools and production of composite ceramics.

Al-W-B composite technological waste.



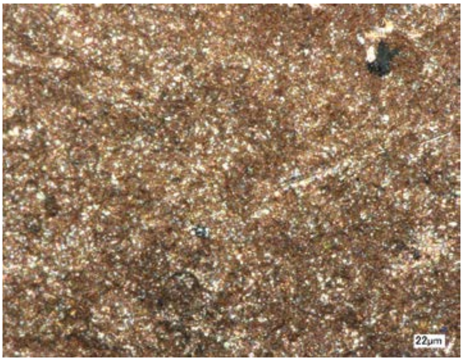
Al-W-B composite micro-structure (with x200 resolution): 1 – boron fibe; 2 – tungsten wire; 3 – aluminium matrix.

Fiber powder Al-W-B.



Microstructure W-B fiber.

Cu-W-B Composite samples.



Microstructure of Cu-W-B composite samples.

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18.2. Research on Construction Materials

Modern industry and construction increasingly call for new complex (composite) materials. Their application allows radically increasing durability and thermal stability of the structures and controlling such materials properties as heat and electrical conductivity, wear resistance, permeability, etc.

Magnetic pulse treatment allows joining heterogeneous materials, for example, aluminum and copper, steel and solid alloys, press fibers, roll powder metallic and non-metallic composite materials. Work in this area was conducted at our laboratory in the 1980's in cooperation with the researchers from RPI Faculty of Chemistry Prof. Uldis Sedmalis, L. Bolshoy and other. Cooperation appeared fruitful – two members of our laboratory staff Igor Molochkov and Vadim Sokolov (Ackerman) developed their theses and successfully passed the viva. New unique materials and conceptually new technological equipment for powder compaction have been developed.

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18.3. Perforated Metallic Materials

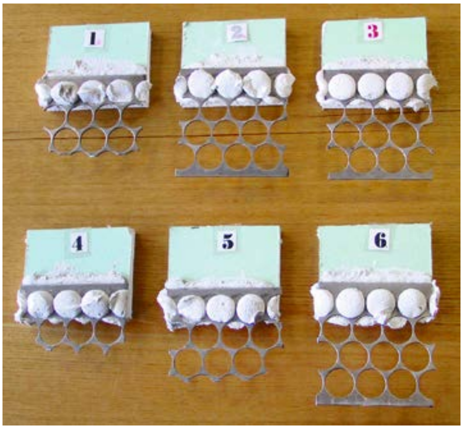
The idea to use technological waste in the form of the perforated steel band appearing in production process at the chain-manufacturing factory in Daugavpils was proposed by the member of our lab staff Igor Legalov in the middle of the 1990's. Initially, the research was conducted within the direct agreements with the enterprises, later the research received funding from the Ministry of Education and Science of the Republic of Latvia and the Latvian Council of Science. The perforated steel band is a valuable product that should not be wasted using it just as scrap metal for remelting. We studied different opportunities to use it more efficiently – for production of high-quality steel powder, reinforcement of concrete building structures, manufacturing of metallic sections. Such members of our laboratory staff as Dmitry Serdyuk, Videvuds Lapsa, Faina Muktupāvela, Irina Boyko, Vyacheslav Zemchenkov and other took active part in this research. In recent years, new ideas to produce cellular structures and sandwich panels from the perforated metallic materials have emerged. In 2012, a member of our laboratory staff Mihail Lisitsin developed his research paper on this topic and successfully obtained his first degree of a Bachelor. The results of research in this area were reported at the international conferences in Riga, Vienna, and Dresden.

Technologies and products manufactured from punched steel strip waste

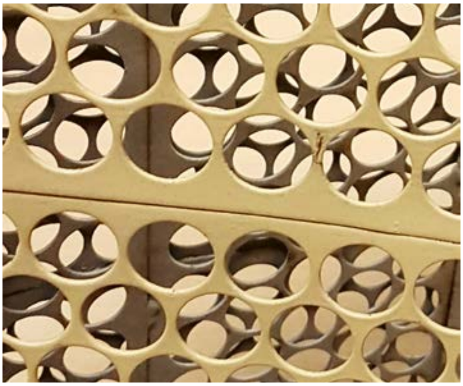
The complete use of material waste is the most significant problem of modern materials science. A possible way to resolve this problem is the effective recycling of industrial waste. The author has revealed some possibilities of the real use of punched steel strip waste for the reinforcement of stonework and concrete and as a material for cables and spacers used when covering floors with concrete.

The efficiency of the use of punched steel strips in construction can be enhanced by profiling. Punched steel profiles are used as a base of the light-weight wall elements and as materials for finishing works. The punched steel strip and the profiles made from the punched steel strip need anti-corrosion protection. Of special attention are investigations focused on the application of such anti-corrosion coatings.

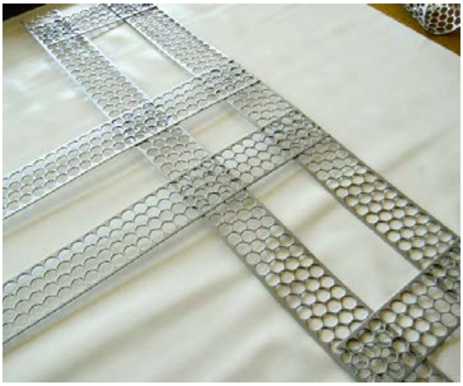
Punched profiles used for the production of inner wall panels.



Connection of punched strip and drywall.



Steel strip frame for concreting.



Application of steel strips for reinforcement of masonry.

Distancers (spacers) for concrete floors.

Tube made from punched strip for cabling.

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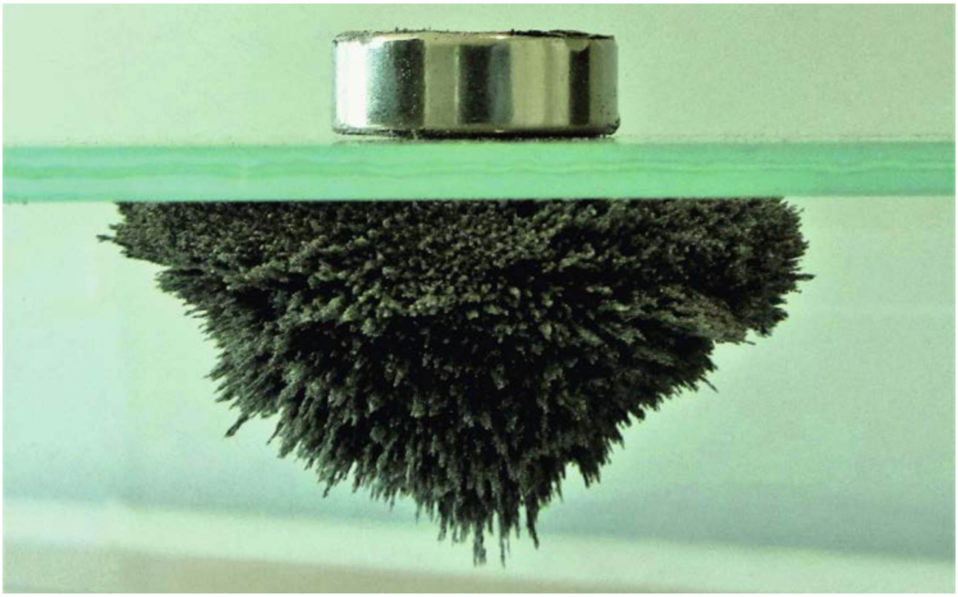
18.4. Ferromagnetic Sorbents

One of the scientific seminars organized by Höganäs AB in 2003 was dedicated to the expansion of the area of application of iron powders. Until then, they had been generally used for production of machine parts and welding

The use of sorbents for oil spill response.



Use of ferromagnetic sorbent.

materials. The growing production of iron powders called for new areas of their application, some of which were proposed by our laboratory. For example, we proposed to use iron powders for production of ferromagnetic sorbents for removal of floating oil spills. Another proposal concerned application of iron powders for production of materials shielding electromagnetic fields. Research in this area has been conducted in our lab since the end of the 1990's. Several types of ferromagnetic sorbents based on iron powders, rolling scale and other materials that appeared promising have been developed. In 2018, a member of our laboratory staff Juris Treijs developed a Doctoral Thesis on this topic and successfully passed the viva.

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19. Development of New Technologies

19.1. Ways to Remove Copper from Solutions

The issue of reclaiming copper from aqueous solutions is highly topical. World production of copper exceeds 10 m tons, and the known reserves of copper constitute almost one billion tons. There are many technological processes connected with copper plating, and production of printed circuit boards is one of them. In production of printed circuit boards, a large amount of copper is wasted in the form of solutions, which pollutes the environment and leads to non-recoverable loss of the valuable resource. RTU in cooperation with the Spanish branch of Höganäs AB conducted research on the extraction of copper from aqueous solutions using a high-speed dispergator-cavitator. Many members of our laboratory staff took part in the research in this area – A. Shishkin, A. Polyakov, J. Baroniņš and other. Processing the powder using the phenomenon of cavitation, copper extraction process becomes more efficient as compared to the known technology associated with the use of a propeller mixer.

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a. Mini- and Microspheres

We got a new impulse in our research during our visit to Fraunhofer Institute for Industrial Engineering in Dresden (Germany). My long-time friend Berndt Kieback invited us to visit the institute, where he headed one of the departments. At the same time, he headed the Department of Materials Science at the Technical

The conference Cellmat 2012, Dresden. Right – Professor Berndt Kiebak.

Minispheres after compaction.

Minispheres in a magnetic field.

University of Dresden. Our meeting was held in a very friendly atmosphere. We remembered his former chief – Professor Werner Shatt, who supervised my research traineeship in the 1980's. Berndt familiarized us with a very interesting new technology – manufacturing of structures from hollow metal minispheres. We were amazed considering new opportunities in production of light structures; we were also fascinated by new areas of research in heat power engineering and dynamics. We obtained the samples of new materials and started working with them. First, we studied only hollow metal minispheres; later, we started to develop new variants of minispheres: multilayered, made from rolling scale, clay, and ceramics. At present, in our laboratory this theme is studied by Dr. Vyachelsav Lapkovskis and Doctoral students – Andrey Shishkin, Pavel Stankevich, Victor Kurtenok and Ervins Blumbergs.

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b. Rubber Crumb

Recycling of the worn rubber tires to produce rubber crumb, which can be further used in production of new materials, is a highly topical issue. Contacts with some specialists from the companies located in Riga and other countries, who work in this area, revealed that there is a growing interest in the research in this field. Production of rubber crumb with ferromagnetic components is the main research fields of our laboratory. This allows addressing yet another new area of research – production of electromagnetic radiation protection shields.

A two-phase technological process for recycling of rubber tires into a rubber-metal powder material was proposed and tested. Application of a high-pressure roller mill together with a disintegrator attested validity of the new concept for development of novel raw material. A European post-doc grant for research in this area was received by the member of staff of the Laboratory of Powder Materials Vyacheslav Lapkovskis.

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20. R&D Activities, Contracts and Projects

Scientific research needs funding – this is an axiom. Until the beginning of the 1990's, the main difficulty was to obtain the funding quotas, which were allocated by the remuneration fund of RPI. There were many customers willing to commission research at our unit, both from Riga and other cities. We maintained regular contacts with the plants in Kazan, Leningrad, Moscow and other cities. Our laboratory also received regular funding from the Powder Metallurgy Plant in Riga.

Starting with the mid-1990's the number of contracted research projects reduced significantly. Direct contracts with Russian enterprises were terminated; western partners did not rush to invest their funds in our research and development. We managed to sign only some agreements with the companies Höganäs AB (Sweden) and Nordeutsch Affinery (Germany). However, it became more and more difficult to find new contracted work due to bureaucratic barriers, unwillingness of the local companies to cooperate with the researchers from the technical university, as well as due to natural lack of confidence of the western companies. We managed to receive some financing with the help of the Ministry of Education and Science of the Republic of Latvia. It was necessary to learn to design and develop projects and submit them for project tenders to win the funding. Nevertheless, we annually received at least minimal funding, which allowed us to sustain the Laboratory of Powder Materials and its stable, although small team.

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21. Promotion of Science and Technology

The accumulated experience in science and technology may become the global commons if information on development and achievements is communicated to the public in a simple and accessible language. I have developed interest in writing popular science books under the impact of seminal books by Jakov Perelman, Aziz Akimov and other scholars. The target audience of popular science normally includes both specialists from other fields of knowledge and the readers without previous background knowledge on the subject, such as students and schoolchildren. Thus, apart from research articles and books I have published several popular science books and brochures, as well as articles in general technical journals.

Cooperation with the magazine *Būvēt* turned out to be particularly long lasting. At the beginning of our cooperation, the editorial board of the magazine, specifically Lolita Rusina, helped me with translation of my articles into Latvian. As a result, more than 30 articles in various areas of mechanization of building construction were published, later many of them were included in the textbooks on civil engineering machinery and mechanization of construction. Some of my popular science books and brochures cover the issues in powder metallurgy and application of pulsed electromagnetic field in technological processes.

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22. Cooperation with Foreign Researchers

During my work in Sweden, I met many prominent scientists (Prof. Fischmeister, Prof. Bockstiegel), however, it was not really possible to maintain regular communication with them, because all correspondence had to be carried out via the Department of External Relationships of RPI, and that was a bit uncouth. From time to time, I met some colleagues at the international conferences organized in Kiev, Moscow or Minsk.

Meeting with the Patron of Klagenfurt (Austria) Mr. Tilo (below). Alexander Polyakov and Leonid Gershanovich.

In 1978, I initiated the signing of the Agreement on Research and Technical Cooperation between Riga Polytechnic Institute and the Westsächsische Hochschule Zwickau – the University of Applied Sciences Zwickau (GDR). Agreements of this kind were highly welcome at that time, but very few succeeded in signing them. Cooperation was mainly limited to students' exchange. The framework of the agreement was transparent and simple – we worked in the same research area and exchanged visits once a year. Each party to the agreement received a group of 2–3 people for a period of one or two weeks providing both accommodation and catering. This agreement promoted our research activity, facilitated exchange of results, experience, and ideas; it also resulted in a number of joint research publications.

In the 1980's, we established close and fruitful contacts with Harry Wolf, Günter Pfrotzschner, and Manfred Mainell. Academic and business contacts actually turned into true friendship. While on their visits in Latvia, German colleagues were invited to visit us in the family setting, and we, in our turn, visited their families. During their stay, we organized various entertainment and cultural events: sailed down the River Gauja, organized boat trips on the River Lielupe. During our trips to Germany, our German colleagues also tried to organize sight-seeing trips in Berlin, Dresden and other cities in Saxony.

Visit of Professor Matthias Kolbe (left) from Zwickau (Germany) to Riga.
Dr. Ing. Vyacheslav Zemchenkov (right), 2012.

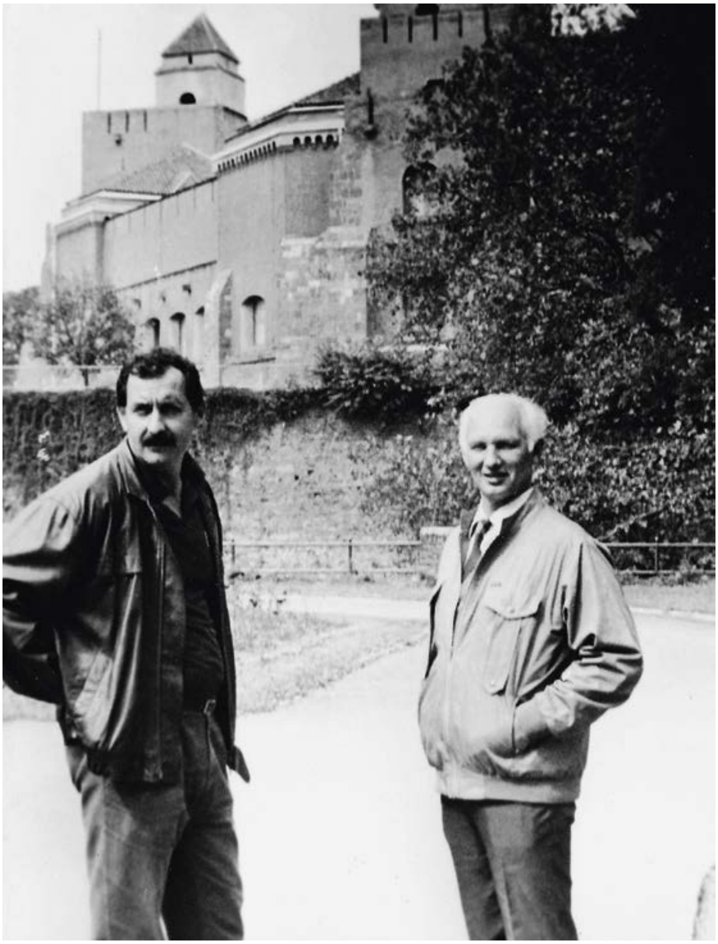
With Academician Jaakob Kübarsepp (Faculty of Mechanics of Tallinn University of Technology), Kyoto, Japan, 2000.

At an exhibition in Minsk (Belarus). Deputy Director of IPM (left), Vadim Savich (center), 2001.

Certainly, we had to stick to the previously reconciled schedule, for example, every day two members of our staff had to accompany German guests. On completion of the visit we had to submit reports on the activities we had performed, moreover, everything had to be coordinated with the head of the Department of External Relations of RTU Ludmila Brondina.

In my opinion, our contacts with the German colleagues from Hochschule Wismar, University of Applied Sciences, Technology, Business and Design in Wismar (Germany) can be considered another case of successful cooperation. RPI was represented by Valdemars Dzenis and the German party was represented by Prof. Gerhard Hake. It was an interesting project dedicated to the development and alignment of research and technical terminology. As a result of our cooperation, we developed an illustrated dictionary covering several areas of mechanization in building construction.

At the beginning of the 1990's our communication terminated. These were hard times not only for Latvia but also for the former German Democratic Republic. Many researchers lost their jobs, for instance, Günter Pfrotzschner (as former activist of the communist party), other moved to Western Germany. We exchanged only some sporadic visits. For example, I remember a professor from a German university in Ulm. We quickly started to communicate on friendly terms; we also exchanged some visits. He presented a pulse welding plant to our



Rada Katana (Serbia) and Prof. Victor Mironov, Ljubljana.

laboratory. It is a real pity that in some years after we met he moved to Mexico. He was very amiable, energetic, and enthusiastic person and a talented scientist. He conducted research on implants from powder materials. Not less interesting was to meet Prof. Wilhelm Tilo from the Austrian city of Klagenfurt. It turned out that his father was one of the patrons of Riga Polytechnicum in the pre-war times. He told us quite a lot about the tragic events before WWII, when he and his family had to leave Riga and move to Germany.

At the beginning of the 2000's, my cooperation with foreign colleagues intensified. I met Prof. Herbert Danninger from Vienna University of Technology, Prof. Frauenfelder from Zurich (Switzerland), Prof. Matthias Kolbe from Zwickau (Germany) and many, many other prominent scientists. The way to the west opened. Now we could freely travel around without the need to submit detailed reports. However, now it became necessary to search for the sources of funding. We received support from the universities of Denmark and Sweden. ERSAMUS program supporting staff mobility for teaching has also contributed a lot to the growth of foreign cooperation.

Starting with 2019, our Scientific Laboratory of Powder Materials has signed several cooperation agreements with the universities in Germany, Russia, Belarus, Austria, and Estonia.

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23. Lectures Abroad

My trip to Poland in 1974 was my first visit abroad as a guest professor to deliver lectures and get acquainted with the specifics of the education process. I went to Szczecin as one of the three members of RPI delegation led by Prof. Egons Lavendelis, who later became Rector of RTU. We received a very warm welcome at Szczecin Polytechnic Institute, visited laboratories equipped with the most modern equipment of that time, which Poland received in large numbers on western credits.

In the following years, I regularly travelled abroad to deliver lectures and conduct research – to Sweden, Austria, Germany, and Belarus. I often travelled with my junior colleagues Vyacheslav Lapkovskis, Irina Boyko, Andrei Shishkin and Aleksey Tatarinov. These visits allowed meeting new colleagues in other countries and learning about new research practices. They also allowed us to get acquainted with other countries – Italy, Austria, Poland, and, of course, Germany. At the same time, extensive academic mobility made it necessary to continuously advance one's professional knowledge and competence and improve foreign language skills.

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24. Participation in Scientific Conferences

I started taking part in scientific conferences during my Doctoral studies in the 1970's. Drawing up and delivering reports at the conferences remain an important aspect of my research work. The opportunity to present one's scientific achievements in a focused way, to summarize results, to answer questions, frequently quite unexpected, is essential for any scientist. In the 1970's and 1980's, the staff of our laboratory (PM Lab of RTU) participated in the conferences in the two main research areas – powder metallurgy and pulse technologies. In the times of the USSR, conferences presented a convenient platform for networking and opinion exchange, conference sections often became the forums for heated argument and discussion. Participation in the conferences and seminars organized in the territory of the Soviet Union was free of charge, airplane and train tickets were relatively cheap and these expenses were covered by RPI. Accommodation was also cheap because as a rule it was organized in the hostels,

V. Mironovs, I. Boiko, V. Lapkovskis, at a conference in Prague, 2011.

each room housing several people. For this reason, a large number of participants attended every conference. The largest conferences in powder metallurgy and pulse technologies were organized in Moscow, Minsk, Kiev, and Novosibirsk. Renowned scientists reported on their trips to international conferences in Japan, Germany, and the USA.

In the mid-1990's, we also gained opportunity to actively participate in the international conferences organized in the Northern countries (Sweden, Finland, Norway). At the initial stage, these countries fully covered conference expenses for the Latvian scientists, however, this scheme was terminated when Latvia joined the EU.

Recently, it has become more difficult to make decisions on conference participation, because conference fees keep growing and the number of conference invitations is constantly increasing. Some conferences have become traditional venues for us, such as European conferences EuroPM, EuroJoin, conferences organized in the Baltics: Baltmattrib, MET, IMST and Connect. We have also greatly benefited from participation in the world congresses on powder metallurgy in Washington (USA), Kyoto (Japan) and other countries.

- World PM /*Powder Metallurgy World Congress*;
- CELLMAT/*Cellular materials*, Dresden;
- Baltsilica/*Baltic Conference on Silicate Materials, Riga, Latvia;*

World Congress PM, Potomak River, Washington, 1996.

- TMT/*Trends in the Development of Machinery and Associated Technology*;
- JOM/*International Scientific and Practical Conference "Joining of materials";*
- *ETR/International Scientific and Practical Conference "Environment. Technology. Resources", Rēzekne, Latvia;*
- Baltmattrib/*International Scientific and Practical Conference "Engineering Materials and Tribology"*;
- MET/Metals, Welding and Powder Metallurgy, Riga, Latvia.

25. Inventions and Patents

Invention activity at Riga Polytechnic Institute was maintained at a very high level. Firstly, there was a patent bureau within the office of the Vice-Rector for Research employing highly qualified specialists – Mara Baltvilka, Aleksandr Chuvailov – who helped draw up invention applications. Secondly, there was a foundation supporting inventors, which provided financial rewards to the authors for the inventor certificates they received and for the use of their inventions. It was also possible to receive remuneration from the enterprises


LATVIJAS REPUBLIKA

PATENTS

Latvijas Republikas Patentu valde apliecina, ka šajā patentā ietvertais izgudrojums ir iekļauts patentu reģistrā ar

Nr. 15292

Patents ir spēkā Latvijas Republikā 20 gadu no 22.06.2016., ja šis termiņš Patentu likumā paredzētajā gadījumā nebeidzas agrāk

Patents piešķirts 20.03.2019. Rīgā

Patentu valdes direktors S. Laganovskis

Patent of the Republic of Latvia.

In the European Patent Office, Munich, Germany, 2004.

upon the launch of the invention. Ownership of inventor's certificates was considered highly beneficial in the process of submission of the Doctoral Thesis for promotion. However, drawing up a patent application one often had to go through a long period of correspondence with the Institute of Patent Expertise in Moscow. The RPI Society of Inventors was a strong player in promoting invention activity. I chaired the Society from 1982 to 1988. Every meeting of the board of All-Union Society of Inventors and Efficiency Experts was held in a different laboratory of the institute, which allowed for wider recognition of the activities conducted at different faculties and promoted networking and cooperation. I would like to recognize continuous support that the Society of Inventors received from the Vice-Rector for Research Andris Starkovs. Among the numerous co-authors with whom I cooperated, I may mention Jury Maksimov, Victor Zhuravlev, Roberts Spunde, Vyacheslav Zemchenkov, Galina Grom, Leonid Gershanovich and many, many other.

One of the main limitations we had to deal with in these years was the restriction imposed on publishing information about inventions, because many of them were classified for official use only.

At the beginning of the 1990's, the old patenting system collapsed.

Patenting activity started to intensify at RTU in the middle of the 2000's. The then-Vice-Rector for Research, Leonids Ribickis, made a major contribution to promoting active application for Latvian patents by RTU staff. One of the most experienced inventors, Dr. Videvuds Lapsa helped our lab to apply for our first Latvian patent, and now their number exceeds 35. We have also gained some experience in applying for Europatents. Patent lawyer of RTU Dr. Irina Boyko has provided us with considerable continuous support in our patenting efforts.

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3. I. C. 387788 USSR, МКИ B 22 f 3/26. Author: Mironov, V. Method of manufacturing of metal ceramic products.
4. I. C. 404565 USSR, МКИ B 22 f 4/02. Method of manufacturing of sintered products. Authors: Mironov, V., Maksimov, Y.
5. I. C. 420476 USSR, МКИ B 30 b 13/00, B 30 b 9/00, B 22 f 3/02. Device for magnetic pulse pressing of powders. Authors: Mironov, V., Maksimov, Y.
6. I. C. 426734 USSR, МКИ B 22 f 3/02. Method for magnetic pulse pressing of powder products. Authors: Mironov, V., Maksimov, Y.
7. I. C. 436547 USSR, МКИ B 21 d 26/14, B 22 f 3/08. Device for magnetic pulse pressing of powders (with samples). Authors: Mironov, V., Maksimov, Y.
8. I. C. 441356 USSR, МКИ C 23 c 8/00. Method of coating of inner surfaces of hollow pieces. Authors: Mironov, V., Maksimov, Y.
9. I. C. 441973 USSR, МКИ B 05 c 7/00. Device for coating of shells with easily fusible coatings. Authors: Mironov, V., Maksimov, Y.
10. I. C. 443549 USSR, МКИ B 22 f 3/14, B 21 26/14. Method of manufacturing of tubular details from powders (with crossbars). Authors: Mironov, V., Maksimov, Y.
11. I. C. 449771 USSR, МКИ B 22 3/00. Author: Mironov, V. Method of manufacturing of metal ceramic products (extrusion).
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24. I. C. 700010 USSR, МКИ B 22 f 3/26. Device for induction infiltration of axially symmetric metal ceramic products. Authors: Mironov, V., Gutfraind, O.
25. I. C. 710787 USSR, МКИ B 22 f 3/02. Device for powder compaction. Author: Mironov, V.
26. I. C. 713066 USSR, МКИ B 22 f 3/ 02, B 22 3/03, B 30 B 12/00. Device for magnetic pulse pressing of long powder products (with movement of powder). Author: Mironov, V.
27. I. C. 745093 USSR, МКИ B 22 f 3/02, B 30 B 15/02. Device for magnetic pulse pressing of powder products. Author: Mironov, V.
28. I. C. 772717 USSR. Device for magnetic pulse pressing of powders. Authors: Mironov, V., Petrov, I., Godes, A.
29. I. C. 784988 USSR, МКИ 22-02/110872. Device for pack molding of products from powder materials. Authors: Gershanovich, L., Mironov, V., Birin, S.
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31. I. C. 799256 USSR, МКИ B 22 f 3/06. Device for centrifugal molding of powders. Authors: Mironov, V., Ackermann, O.

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45. I. C. 900979 USSR. Device for magnetic pulse pressing of powders (with heating and oil filling). Authors: Mironov, V., Ackermann, V.

46. I. C. 900980 USSR. Device for magnetic pulse pressing of powders (with powder nip). Authors: Mironov, V., Zemchenkov, V., Solovyev, S.

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50. I. C. 929327 USSR, МКИ B 22 f 3/02. Method of magnetic pulse pressing of powder materials. Authors: Mironov, V., Kot, A.
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26. Sports Supports Science

In my opinion, a person can be productive in science if he or she leads an active sports life. Some members of RPI staff might still remember the meeting of RPI Council when then-Rector Aleksandrs Veiss in a way ordered all senior staff members to regularly go in for sports and attend the gym. This, *inter alia*, led to the establishment of RPI staff volleyball team. I was an active member of this team for almost 25 years. The construction of a sports complex with a swimming pool on Kipsala Island became an important step in the life of RPI and later RTU.

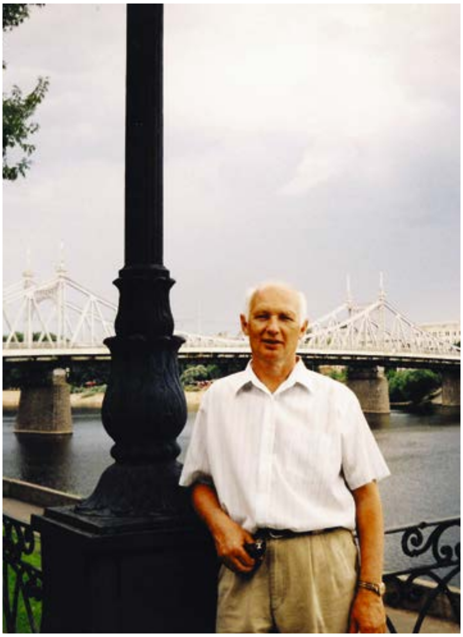
27. Family Values

Family values are very important. Family provides a stable and continuous support, it helps to survive in difficult times. Throughout my life, I have always maintained contacts with my relatives in Tver (mother, sister, and brother). For 60 years now we have been together with my wife, Vera. Together we studied at the college and the institute, raised a daughter and grandchildren. We help them to raise children, our great-grandchildren.

Veteran volleyball team of RTU-VEF, 2008.

Engineers Victor and Vera Mironov. Riga, 1967.

In the family, 1990.



In the hometown of Kalinin (Tver), 2011.

Vyacheslav Mironov – Rector of TvGTU.

The core of the family clan (Andrei Turulin, Viktor Mironov, Oleg Fillipov and Pavel Stankevich) Babite, 2016.

Vera and Victor Mironov with daughter Maria, Riga, 1967.

Victor and Vera Mironov. Meeting after one year spent apart upon V. Mironov's return from Sweden, where he was doing his scientific internship, 1975.

Victor and Vera Mironov. 60 years together, Riga, 2018.

In the family. Sister Olga (left) and mother Catherine (center), Tver, 2010.

With beloved granddaughters Anna and Victoria.

With great-granddaughters Nastya and Sonya, Babite, 2016.

My great-grandson – Ruslan, 2018.