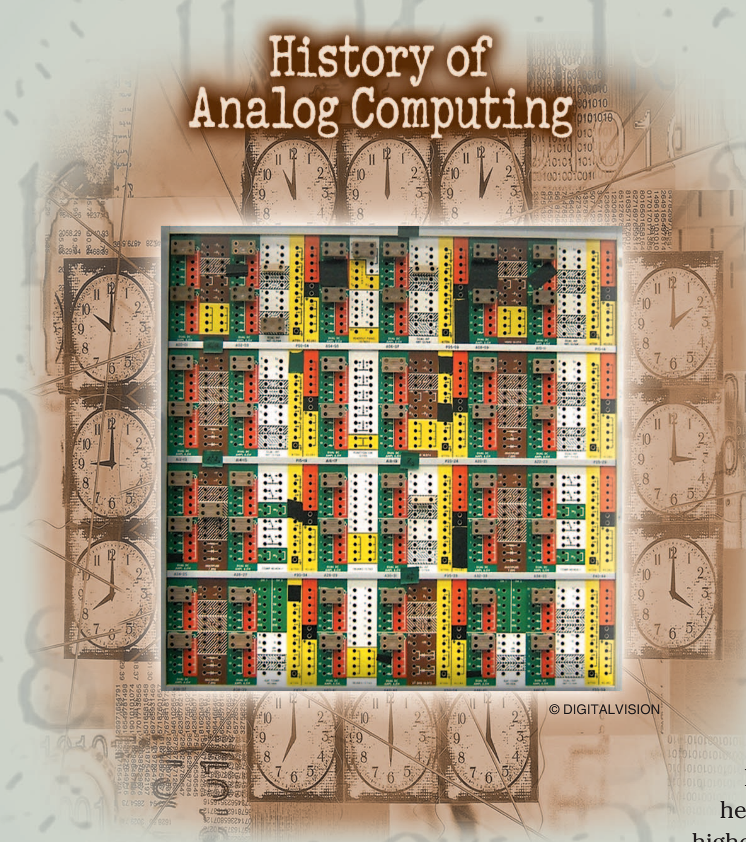
FEATURE

Analog Computing in the Soviet Union

An interview with Boris Kogan

By Daniel Abramovitch



The early days of simulating dynamic systems were dominated by analog computers. In the Soviet Union, electronic analog computers were developed both at the Academy of Science and in industry. These developments occurred at the same time as, but independently from and unaware of, the work of Lovell, Philbrick, and Ragazzini in the West. See [1]. The principal investigator at the Academy of Science was Boris Yakovlevich Kogan [2].

We are graced by the fact that Boris Kogan is available to talk with us. Prof. Kogan has had a fascinating career in the most formative years of the control field, and although his name is not as well known to many Western control engineers as some of his Soviet-era contemporaries, it is clear that his pioneering work on simulating complex systems, including the development of the Soviet Union's first analog computers and hybrid computers, was critical to the control work being done then. A researcher with a Ph.D. in control systems in the Soviet Union at the height of the Cold War, he was awarded the Soviet Union's highest medal, the Stalin Prize, for his work. He was one of the few Jewish researchers not fired from his position at the beginning of 1950s when Stalin was preparing to move all of the Soviet Union's Jewish population to Siberia.

Prof. Kogan wrote a book on analog computing in 1959 titled *Electronic Analog Computers and its Application for Investigation of Automatic Control Systems* [2]. Originally written in Russian, his book was entered into the machine translation system at Wright-Patterson Air Force Base in Ohio (part of the Foreign Technology Division of the Air Force Systems Command) by Granino Korn and can be obtained (with some difficulty) at libraries specializing in aerospace technology. The book was also translated into Chinese in 1960 and later into Hungarian, Polish, and German.

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When Prof. Kogan applied to emigrate from the Soviet Union 30 years later, he lost his position at the Institute of Control Science. He emigrated in 1987 at the age of 73 and has since settled in Santa Monica, California. He joined the UCLA Computer Science Department as an adjunct professor. The department was then cochaired by Dr. Walter Karplus, an American pioneer in simulation (analog, hybrid, and multiprocessor digital), who had known Prof.

Boris Kogan: A Short Biography

Dr. Boris Kogan (Figure 1) is an adjunct professor at the University of California, Los Angeles, Computer Science Department. He received his B.S. and M.S. degrees in electrical engineering from the Charkov Electrical Engineering Institute, U.S.S.R., in 1938. He received his Ph.D. degree in automatic control from the Moscow Institute of Automation and Telemechanics at the U.S.S.R. Academy of Sciences in 1945. Dr. Kogan also received the doctor of engineering sciences degree (in computer science) from the Air Force Military Academy, Moscow, U.S.S.R., in 1962.

In the former Soviet Union, Dr. Kogan's scientific activity was devoted to research in the field of automatic control, computer design, and computer simulation. He worked at the research Institute of Control Science in Moscow from 1940 until 1981 as a junior researcher, a senior researcher, and the first director of the Computer Simulation Laboratory that he created. Prof. Kogan lectured part time as a full professor in the Moscow Institute for Physics and Engineering from 1948 until 1980. He received the U.S.S.R. State Prize in 1951 for creating the first analog computer.

Figure 1. *Prof. Boris Kogan in his office at UCLA. Prof. Kogan now applies his considerable expertise to cardiac simulation. At age 90 he is still advising students.*

During Prof. Kogan's career in the Soviet Union he was a highly renowned researcher, traveling globally. He met Walter Karplus and other American analog computer experts at the first IFAC Congress in Moscow in 1960, starting a 40-year friendship with the former. Prof. Kogan collaborated with Granino Korn as each worked to translate the other's book into their country's language. He frequently traveled to Yugoslavia to give lectures, where he met a graduate student named Petar Kokotovic. Later, when Kokotovic wanted to study in Moscow to work at the Institute of Automatics and Telemechanics (which was closed to foreigners), it was Prof. Kogan who connected him with Prof. Alexander Feldbaum and Prof. Jacob Tsypkin. Prof. Kokotovic has nothing but praise for Prof. Kogan, referring to him as a mentor, as someone in whom he had 100% trust, and as someone who managed to speak his mind and keep his position in a place and time that usually made those attributes mutually exclusive.

In addition to the U.S.S.R. State Prize (the Stalin Prize), which he won in 1951, Prof. Kogan received numerous other awards [16]:

- a Chinese Medal "Soviet-Chinese Friendship" for contribution to the first Chinese analog computer project in 1958
- Grand Prix a l'Exposition International, Bruxelles in 1958
- Gold Medal, U.S.S.R. National Economic Achievement Exhibition in 1964
- Gold Medal, U.S.S.R. National Economic Achievement Exhibition in 1975.

After immigrating to the United States in 1987, Prof. Kogan's research interests have transferred from automatic control, analog and hybrid computers, and computer simulation to the investigation of electrical wave propagation in excitable media (special type of nonlinear distributed in space dynamic systems) using massively parallel digital computer systems. In conjunction with cardiologists, this study focuses on peculiarities of electrical wave propagation along healthy and diseased heart muscle to find the mechanisms of heart fibrillation and the corresponding preventing means. He has continued to teach and supervise graduate students at an age when most researchers have long retired. In 1994 he was honored with a special symposium at UCLA celebrating not only his early career but also his incredible level of activity since his immigration [16]. He has published over 120 papers and is the author of two books.

Dr. Kogan is an editorial board member of the *Transactions of the Society for Computer Simulation* and a member of the American Heart Association and the Society for Computer Simulation [17].

Kogan since the 1960 IFAC congress in Moscow. At UCLA, Prof. Kogan has continued his work on complex dynamic system simulation, now on supercomputers. At the same time, he has worked to help Soviet émigrés settle in the United States and find meaningful work. His professional and personal work since his arrival have won him accolades from far and wide, and he shows no sign of slowing down today.

The First Soviet Analog Computer

Interviewer (I): *Can you describe the original analog computer that you worked on?*

Boris Kogan (BK): The original electronic analog computer that we developed was capable of solving sixth-order linear differential equations with time-variable coefficients in real time. This allowed the simulated part of a control system to be connected directly to the part of real control system hardware that had to be adjusted and tested. For example, the analog computer could be used to implement the mathematical model of the control system object (such as the linearized equations of flight dynamics around one of the gravitational axes) and connect this to the actual controller hardware (corresponding channel of the autopilot). These days, such a system is called an embedded system. Our analog computer had a so-called "structural architecture." This was in contrast to the matrix type architecture (Figure 2) proposed at the same time by Prof. A.A. Feldbaum, who worked then in the R&D department with V.B. Ushakov, a principal investigator in industry who with his group were cowinners of the Stalin Prize in 1951. We used high gain dc operational amplifiers with deep negative feedback constructed on electronic tubes and passive linear circuit elements. They formed the basic linear elements: integrators, summing elements, and sign inverters. The potentiometers controlled by special servomechanisms were used to introduce the variable-in-time coefficients into the analog computer setup (the mathematical model of the part of the overall control system).

I: *What were the origins of the machine?*

BK: At that time there were no such computers in the Soviet Union that were capable of simulating the control systems or their parts in real time.

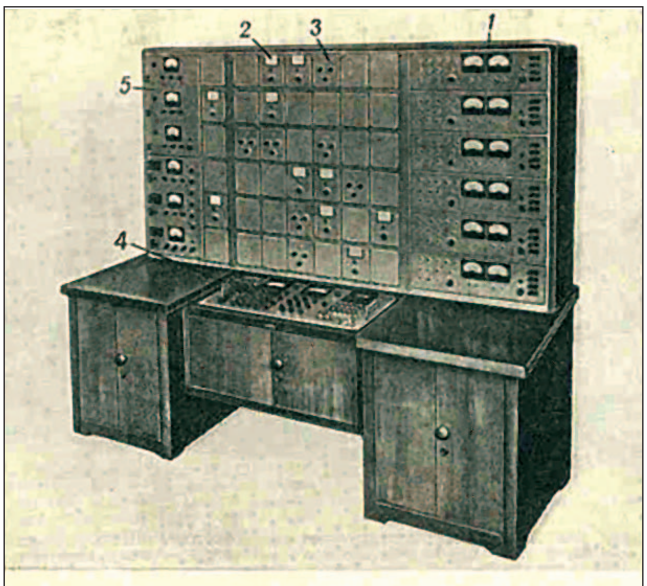

Рис. 241. Электронная моделирующая установка типа ИПТ-4 (промышленный образец). 1 — блоки решающих усилителей, 2 — блоки переменных коэффициентов, 3 — блоки постоянных коэффициентов, 4 — пульт управления, 5 — входные блоки.

Figure 2. *One of the first Soviet analog computers, the IPT-4 developed in industry. The principal investigator was V.B. Ushakov, with the major ideas developed by Dr. A.A. Feldbaum. The translated caption reads "Figure 241 Electronic simulation device ITPT-4 (industrial prototype). 1-modules for linear operation (operational amplifiers), 2-modules of adjustable coefficients, 3-modules of constant coefficients, 4-control console, 5-input module. The device is intended to solve ODEs up to 6th order with constant and variable coefficients." (From [1, p. 435].)*

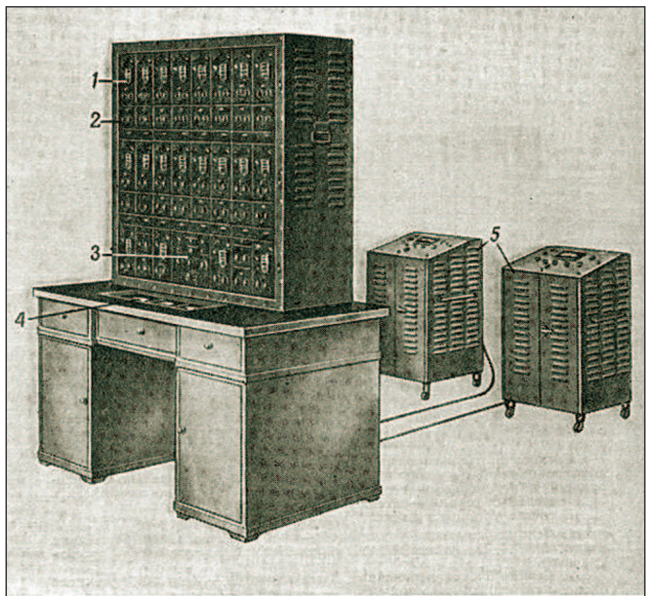

Рис. 244. Электронная моделирующая установка типа ЭМУ-2 (АН СССР). 1 — блок решающего усилителя, 2 — блок постоянного коэффициента, 3 — пульт управления, 4 — блок настройки, 5 — блок питания.

Figure 3. *The model EMU-2 analog computer developed under Boris Kogan's leadership in the Institute of Automatic and Remote Control at the U.S.S.R. Academy of Sciences in Moscow. The translated caption reads "Figure 244 Electronic simulation device EMU-2 [AN SSSR (Academy of Sciences of the U.S.S.R.)]. 1-module of linear operation elements (operational amplifiers), 2-modules of constant coefficient, 3-control console, 4-tuning module, 5-power block. The device is intended to solve ODEs up to 10th order with constant and variable coefficients." (From [1, p. 438].)*

I: *Who worked on it with you?*

BK: In my team worked a group of engineers and technicians. Among them, S.I. Bernstein and M.A. Shneidman made the great contributions to the creation of the first prototype of the analog computer. I was responsible for overall design principles and simulation of the missile dynamics over the center of gravity with autopilot.

I: *Are there any images of or diagrams for that computer?*

BK: Unfortunately I did not find a photo of the first version of our analog computer. A photo of the second version (Figure 3) is in my book. The design principles were first described in [3].

I: *When was the computer designed and built?*

BK: The first computer, the EMU-1 (EMU is the Russian abbreviation of the English words "electronic simulating devices"), was created during the period 1947–1949. A series of improved EMU-type computers followed: EMU-2 and EMU-3 for solution of linear ODEs, EMU-5, 6, and EMU-8 for solution of linear and nonlinear ODEs. The general-purpose analog computer EMU-10 with parallel logic was used as a standalone computer and as a part of the hybrid computer system. We also developed a special-purpose, high-speed analog computer, which was used in optimal control systems with prediction [4].

Several types of this series were manufactured by industry (EMU-8, EMU-10). Many original ideas were proposed and introduced in these analog computers by the research staff of my laboratory. Here it is necessary to mention Dr. Polonikoff (operational amplifiers and A/D, D/A converters), Dr. Maslov and Dr. Talancev (nonlinear function blocks), and Dr. Michailov and Eng. Gurov (overall design).

I: *How many were built?*

BK: I have no statistical data.

I: *Are there any surviving machines in museums or institutes?*

BK: I have no idea.

I: *How were they used?*

BK: Predominantly in military organizations for simulation of flight control problems. Once I helped Mikhail Botvinnik, then the World Chess Champion and Ph.D. in electrical engineering, to solve his research problem in electrical power systems by using one of our analog computers. There are the corresponding references in one of Botvinnik's books. (See "Mikhail Botvinnik.")

I: *What were the hybrid computers like?*

BK: The first hybrid computers in the Soviet Union and Eastern European countries were developed as a united whole system of specially designed digital mini computers connected trough the D/A and A/D converters and the digital control system to the specially designed universal wide-band analog computer, which was provided with the so-called parallel logic. This hybrid computer system (HCS-100) was developed and designed through the mutual efforts of several labs in the Institute of Control Science of the U.S.S.R. Academy of Sciences and the Institute of M. Pupin in Belgrade, Yugoslavia (1969–1971). The idea of creating the modern hybrid computer system belonged jointly to me and to the then well-known Serbian Prof. Raiko Tomovich (Petar Kokotovic's boss in Yugoslavia). Prof. Tomovich put in great efforts to make possible such kind of international research

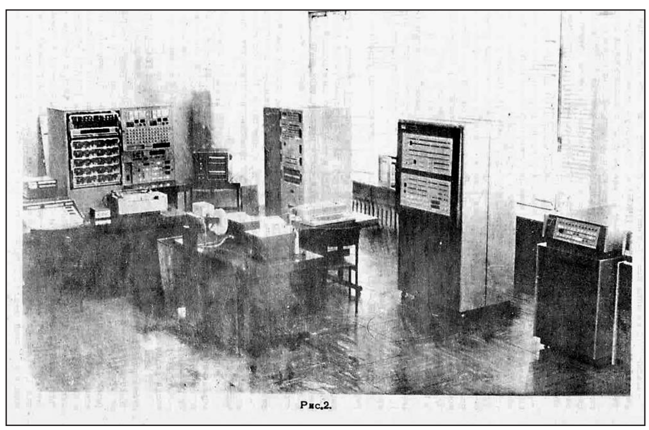

Figure 4. *Hybrid computer model HCS-100, developed by the Institute of Control Science (U.S.S.R.) and the Pupin Institute, Yugoslavia, under Boris Kogan's leadership. From left are shown: analog part, A/D and D/A converters, digital part, one of the magnetic disk units. In the center are arranged the control desk and input/output blocks. (From [6, p. 12].)*

Mikhail Botvinnik

Mikhail Botvinnik is probably far better known to the chess world than the engineering world. Here is an excerpt from [5]:

Mikhail Moiseevich Botvinnik was born in St Petersburg, Russia in 1911. He learned to play chess at the age of 12. An electrical engineer by training, he was the first Russian to hold the World Championship title after he won the 1948 tournament following the death of Alexander Alekhine. He held on to the world title until his defeat by Petrosian in 1963, except for two occasions when he lost the title for one y ear, to Smyslov (1957–1958) and Tal (1960–1961). Botvinnik was very serious about chess and never played for fun.

cooperation project to be organized. To get some idea of how much effort this involved, it is necessary to emphasize that in those days Yugoslavia under Tito was considered by Soviet Authority as a capitalistic country.

I was elected as scientific principal investigator of the entire project, and Dr. P. Vrbavac and Dr. G. Konstantinov as the coinvestigators from Yugoslavian site. The project was successfully accomplished in 1971, and HCS-100 (Figure 4) [6] was manufactured in Yugoslavia (Figure 5). During 1971–1974 in my lab in the Institute of Control Science, we developed another hybrid computer system (Figure 6) [6], the *Rusalka*, which means mermaid in English. Many original ideas were proposed and implemented in this project by my collaborators, Dr. Menn, Dr. Kazmin, Dr. Polonnikov, and Dr. Michailov. This hybrid computer system had a hierarchical type of architecture and used commercially available digital computers.

Figure 5. *Image of a hybrid computer, model HCS-100, produced in Yugoslavia and put into operation at the Institute of Katalis Novosibirski branch of Academy of Sciences U.S.S.R. in 1975. This photo shows, from left, the analog part and box with A/D and D/A converters and desk with control console. The joint Soviet-Yugoslavian starting team is shown. Principal investigator Prof. B. Kogan and the vice-director of the Pupin Institute are seated from right to left. (From Boris Kogan's photo archive.)*

Figure 6. *The hybrid computer "Rusalka" (Mermaid) developed under Boris Kogan's scientific leadership. The translated caption reads:* "*Figure 3: General view of GVS "RUSALKA.*" *(From [6, p. 19].)*

Both hybrid computer systems allowed us to carry out large-scale computer simulations of complex dynamic systems. Particularly, Dr. Gulko and Dr. Petrov were the first to show the spiral-wave phenomenon in cardiac tissue by computer simulation. This research was inspired by the work of Prof. Mina E. Rajskina, MD [7], then chief of the Myocardial Infarction Laboratory at the Russian Cardio Center, and was the result of mutual research efforts of the staffs of our laboratories. Prof. Rajskina's book [7] describes this story and many others. Later, when I resettled to the United States in 1987 and restored my research activity at UCLA, I modified the hybrid computer algorithms for digital parallel supercomputers and continued the investigations of spiral wave propagation (considered as analog to arrhythmia and fibrillation) in the heart using a computer simulation approach [8], [9].

I: *When did the change from analog to digital computing come for advanced simulations in the Soviet Union?*

BK: It seems to me from the end of 1960s to the end of 1980s, the time of creation and manufacture of digital high-speed computer (BESM-6) developed by Institute of Computer Technique and Fine Mechanics (Academician S.A. Lebedev).

Life and Work in the Soviet Union

I: *You received the State Prize from Joseph Stalin in 1951 for the invention of the analog computer.*

BK: I received the Stalin Prize in 1951 as a principal investigator together with another principal investigator from industry (V.B. Ushakov and his team). Our projects, developed independently, were combined for the award. We did not invent but rather developed this type of computer. We lived then in U.S.S.R. in conditions of "iron curtain" and had no access to the technical information from the West. That is why our technical solutions to some extent were new and to some extent had some drawbacks. It is also necessary to take into consideration that these works were classified in the first stages not only in the Soviet Union but in the United States as well.

I: *A question about the isolation here: In the United States much of the missile simulation work was done in Huntsville by von Braun's team that included Helmut Hoezler, who worked on simulations of the V-2 in Peenemünde. I recall* *reading about how part of the German rocket team went east to the Soviet Union and part of them went west to the United States (von Braun's team). Did you see any of the team that went east?*

BK: No. To the best of my knowledge, the German rocket team such as von Braun's team never went east to the Soviet Union. I knew about the separate scientist in gyroscopy who worked in the Soviet Union in a special lab, but they had no idea about the whole rocket design and simulation of rocket dynamics. I was in Germany in 1946 and participated in restoring documentation on automatic control system used in German rockets.

I: *Also, Ed Feigenbaum, who won the Turing prize for his work at Stanford on artificial intelligence, visited the Soviet Union twice in the early 1960s. He was at the 1960 IFAC Congress. Did you happen to cross paths with him?*

BK: Unfortunately, no. I met on this IFAC Congress with Dr. Karplus, Dr. Paynter, Dr. Philbrick, and other members of the American delegation. (Figure 7 shows Dr. Kogan meeting with Dr. Karplus and Dr. Paynter.)

I: *You were given the State Prize by Joseph Stalin. What was it like to meet him?*

BK: No, Stalin himself never handed the prize to winners. I received it from Academician Trofim Denisovich Lysenko, who later was recognized as a pseudoscientist, a scientist who falsified the obtained results. He was an ignorant agricultural practitioner who destroyed genetic investigations in Soviet Union for a long time, but this is another topic. (See "Trofim Denisovich Lysenko.")

I: *You were a research director of the Mathematical Modeling and Computer Simulation Laboratory in the Institute of Control Science, Academy of Sciences U.S.S.R. from 1946 to 1981.*

Figure 7. *At the First IFAC Congress in Moscow, 1960, Prof. Kogan discusses analog computation problems with his American colleagues. From right: Boris Kogan, Walter Karplus, and Henry Paynter (far left). The identity of the researcher partially obscured by Dr. Paynter is not known.*

Trofim Denisovich Lysenko

Trofim Denisovich Lysenko is a dark figure in the history of Soviet science. I believe Prof. Kogan is being generous in his description of the man, both from conversations with other engineers from the Soviet Union and information that is available elsewhere. The following information is from [10]:

> Born in Karlovka near Poltava. Graduated from Kiev agricultural institute in 1925. In practical plant-raising, followed [Ivan Vladimirovich] Michurin. Rejected the chromosome theory of heredity generally accepted by geneticists. Postulated that hereditary changes to plants could be induced by environmental influences, e.g. subjecting grain to extreme temperatures or injections.
>
> Insisting that this theory corresponded to Marxism, he successfully attracted official support of the Party to his side. He was named president of the Academy of Agricultural Sciences in 1938. He began a persecution of those colleagues who did not agree with his theories, notably the founder of the Academy, Vavilov (who was deprived of work, arrested, and died in the Gulag).
>
> Became dictator in biological sciences under Stalin, whose cult he supported. In effect, he became a Stalinist deputy for science, like Zhdanov for culture, Voroshilov for the army, Beria for everything in the country. [Lysenko] was personally responsible for the exile, torture, and death of many talented scientists, and for an environment of oppression and backwardness in Soviet science.
>
> After World War II, in the fever of Stalinism, there arose a scandal in the world scientific community over his reliance on Party authority in scientific discussions.
>
> After the death of Stalin, TDL was personally criticized by Khrushchov[sic.] in March 1953. He was relieved of his post as president of the Academy of Agricultural Sciences in 1954, after 16 years of terror against scientists. Nevertheless, he retained a position as personal advisor to Khrushchov[sic.] on agriculture. In following years, it was shown that he had sometimes falsified experimental results to support his theories.

(Translated from J. Vronskaya and V. Chuguev, "Kto Est' Kto v Rossii i Byvshem SSSR," ("Who's Who in Russia and the Former U.S.S.R.") "Terra," Moskva, 1994. Copyright © 1992 J. Vronskaya and V. Chuguev.)

Commemorating Kogan's 90th Birthday

On 22 October 2004, UCLA's Computer Science Department held a special commemorative celebration of Boris Kogan's 90th birthday (Figure 8). In attendance were luminaries from UCLA and the world of analog, hybrid, and supercomputer simulation. The evening's master of ceremonies was Leonard Kleinrock, known throughout the computing world for his pioneering work on packet switching networks and the creation of the Internet (then known as the Arpanet). UCLA Dean of Engineering Vijay K. Dhir pointed out that the Soviet Union's loss in 1987 was UCLA's gain. Prof. Kleinrock noted that Boris was a role model for the rest of the faculty. He also said that Boris was the best connected scientist that he had ever met from the former Soviet Union, and yet he was willing to give up his position when his beliefs were challenged. More than 20 years after his position at the institute was revoked, his former colleagues remember him with great fondness and admiration.

Figure 8. *Boris Kogan's 90th birthday celebration. In the center is Prof. Kogan. His wife Mina Rajskina and George Bekey are to his left. To his right are Master of Ceremonies Leonard Kleinrock and his wife Stella Schuler Kleinrock.*

Prof. Kleinrock also noted Boris' habit of asking seminar speakers insightful questions such as "Tell me, exactly what is your contribution," which has a devastating effect on many of them.

Prof. Alan Garfinkle [9] stressed the importance of Boris' work to the area of electrophysiology. He also related a story of how Boris, before applying for immigration, had written a book with a student. Once he applied to immigrate, the book was published in the Soviet Union but with Boris' name removed.

Petar Kokotovic relayed a story about how he had visited the Soviet Union in 1974 as part of the American delegation for a conference on the joint Apollo-Soyuz project. At the time he had an American green card but a Yugoslav passport. Upon arrival, the passport checker told him that he could not be traveling with an American visa and a Yugoslav passport. He instructed Petar to go to a particular police station to have the matter resolved. Petar checked with

What was it like to work as a scientist in the Soviet Union in those days? Did the fact that you are Jewish affect your status as a researcher?

BK: Yes, I was a researcher with Ph.D. degree in automatic control received from the Institute of Automatic and Telemechanics (in Moscow) in 1945. I worked in the post-war Soviet Union at the Institute of Automation and Telemechanics in the Academy of Sciences, U.S.S.R., which later was renamed as Institute of Control Science Problems. I founded the Mathematical Modeling and Computer Simulation laboratory in this Institute in 1959 and was its scientific director until 1982, when I applied for permission to emigrate.

Before 1948, I did not feel the state anti-Semitism in the Soviet Union. I met with it personally in the end of 1952 when Stalin decided to resettle all the Jews to Siberia and a special party commission was sent to work in our institute. As the results of this commission activity, all Jews in our institute except me and Dr. Aizerman, Dr. Tzipkin, and Dr. Meerov were fired. I suppose that I was not fired only because of recent Stalin's award. To realize how strong this anti-Semitic company affected the Jews of our Institute, it is important to mention that before 1952 about 60–65% of the scientists in our Institute were Jews. During all this time there was a state effort to introduce Marxism-Leninism dogmas into different sciences. For example, these efforts were carried out: in biology science against Morganism and Mendelism (genetics), in physics against the theory of relativity, against cybernetics, against cosmopolitanism, and so on. It was required that each of us state our opinion, which had to be aligned with those officially approved by the Communist Party. Moreover, very often scientists were required to sign letters against some outstanding scientists such as Dr. Sacharov and other so-called dissidents. For me this situation in which it was necessary to think, to express your opinion, and to act differently from my personal beliefs became unbearable. After the departure of my brother to Israel, I decided to leave the Soviet Union.

his friends in Moscow from his days as a student, and they told him in no uncertain terms that under no circumstances should he go to that station—that people who went to that police station did not emerge. So, he went to the conference with this on his mind, wondering how he would actually get out of the country in a few days. The conference itself was well stocked with KGB agents, so he had no idea who to talk to. However, he did have total confidence in Boris. Boris assured him, "We'll go to the airport together," and accompanied him to the airport. At the gate, there were two Pan Am agents: an American to take the ticket and a Soviet to check immigration. The Soviet ticket agent said that the visa was invalid and the police would have to be called. At this point, Boris stepped up, waving his official credentials, pointing out that Petar was an official guest of the state and that the agent should not "embarrass him." While he was doing this with one hand, he was pushing Petar to the gate with the other hand. Thus, the American agent took his ticket, and Petar got on the plane and made it home safely. Petar was quick to point out that in his opinion and in that society at the time, Boris was taking a huge risk to help a friend.

George Bekey talked about the three stages of Boris' career:

- 1937–1946: The control of industrial processes. In the Soviet Union, he was a pioneer in using control for paper mills. His first paper was published in 1940.
- 1946–1975: The control of rockets and missiles and the development of analog and hybrid computers. This stage started when Boris was sent to Germany in 1946 to learn how the Germans controlled rockets. He returned with several pieces of automatic control systems. He worked on surface to air missiles starting in the late 1940s, about the same time that Bekey himself was working on ICBM simulation at TRW.
- 1964–present: The computer simulation of biological systems. In 1964 Boris met and started working with Prof. Mina Rajskina, a noted cardiologist in the Soviet Union. This collaboration affected his life in two ways. First he started working on the study of arrhythmia, in which the electrical pattern of the heart changes dramatically. Second, he and Dr. Rajskina soon were married.

Two of Boris' grandchildren were in attendance, and one of them, Eugene Gravner, spoke about his grandfather. Eugene spoke of growing up in Southern California with grandparents whom most of his contemporaries envied. He also showed an image of his grandfather Boris in mountain biking gear.

At the end of the event, Boris got up to speak, thanking the attendees. He had several general points to make:

- As a control engineer, he cannot find a more interesting system than life.
- Marriage is like the number π: It is natural, irrational, and necessary.
- Living in the United States gave him the first feeling of freedom that he had in his life. He finished with a simple "God bless America."

Interviewer's Note: *Between 1948 and his death in 1953, Stalin grew increasingly anti-Semitic, purging Jewish cultural institutions, eliminating Jewish intellectuals, and framing a set of mostly Jewish doctors in the so-called "Doctors Case (Plot)". As an example of the effects of party politics on science Lysenko was able to use party approval of his anti-genetic views to exile scientists who disagreed with him.*

Contemporaries

I: *You said that you were tightly connected with Prof. Tzypkin, Prof. Aizerman, Prof. Feldbaum, and other outstanding scientists of this Institute. Can you tell us about those individuals and your interactions with them?*

BK: Yes, I was tightly connected with the outstanding scientists of this Institute. This is a long story. A few that I can mention briefly:

Jacob Tzypkin and I defended our doctoral theses on the same day before the same commission (thesis committee) at the Institute of Automatic and Telemechanics in Moscow in 1945. I wrote my remembrances about him in special issue of the *International Journal of Adaptive Control and Signal Processing* [11].

M. Aizerman and I participated in the same seminars and different scientific commission, as members of the editorial board of the *Journal Automation and Telemechanics*.

A. Feldbaum and I started working in the same field of computer simulation. He was one of the reviewers of my book on analog computers and its application to study the automatic control systems. I also interacted with A. Gavrilov who developed the theory of switching circuits. A.M. Letov worked in my lab for a short time. I also worked with A. Lerner on creation of optimal control systems with prediction. We all participated in writing the books in advanced topics in automatic control theory and practice.

I: *Petar Kokotovic mentioned that you knew Tsien Hsue-shen, the father of China's rocketry program.*

Tsien Hsue-shen

Dr. Tsien Hsue-shen is himself a fascinating subject of history for control engineers. Born in 1911 in the eastern Chinese city of Hangzhou, he went to study at MIT in 1935 and then at Caltech in 1936. He earned his doctorate in 1939 and stayed at Caltech, eventually becoming one of the leading rocketry experts in the United States and the cofounder of the Jet Propulsion Laboratory. Falsely accused of being a Communist when he applied for American citizenship in 1950, he announced his desire to return to mainland China. Held in house arrest for close to five years, he was deported in 1955, deliberately leaving his research papers at Caltech. He immediately went to work in China founding the Institute of Mechanics and building China's ballistic missile program. He is largely considered the father of Chinese rocketry. Information on Tsien can be found in [12], and he is the subject of a biography in the popular press [13].

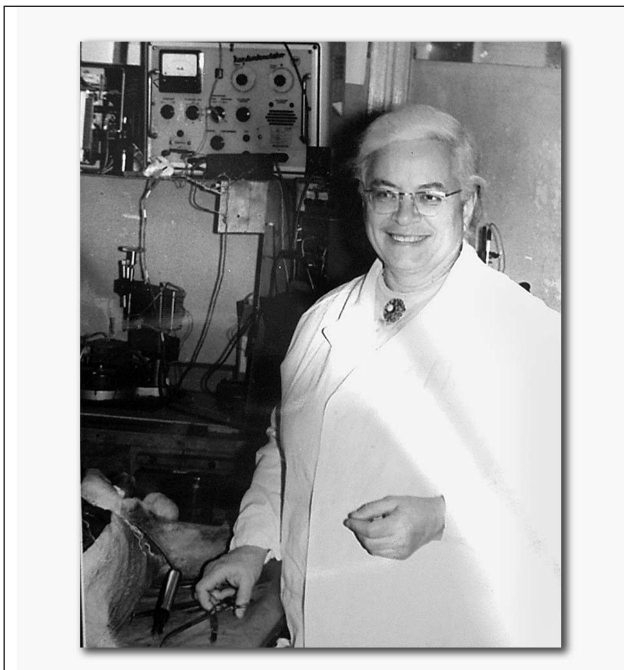

Figure 9. *Dr. Mina Rajskina, Prof. Kogan's wife, was a noted cardiologist in the Soviet Union when she and Boris first met, collaborating on simulation studies of cardiac functions. The manuscript for her book,* Ventricular Fibrillation and Sudden Coronary Death (Developments in Cardiovascular Medicine)*, was smuggled out of the Soviet Union with help from the Dutch Embassy when she and Boris emigrated in 1987. The translation was later published in the United States [7].*

BK: I met Dr. Tsien Hsue-shen during my visit to China Academy of Sciences Institute for Automation and Remote Control in 1958. Then he was the director of the China Institute of Mechanics and a world-recognized scientist in control theory. We met several times to discuss topics of mutual interest.

Emigration

I: *You were a Jewish engineer in the Soviet Union. You emigrated in 1987. You were at the Institute until 1981. Between 1981 and 1987, were you trying to emigrate? Were you a refusenik?*

BK: I was considered in the Soviet Union as a scientist of Jewish nationality. Starting in 1981, I tried to get permission for emigration and was refused. Every six months after that, I reapplied and was refused. In between the refusals, I was allowed to do nothing. However, my wife, Mina Rajskina (Figure 9), and I were occupied in writing the manuscripts, in which we tried to summarize our scientific results. I also regularly attended the scientific seminars organized by some refuseniks. We finally got permission to emigrate in 1987. By that time my manuscript, *Theory and Application of the Hybrid Computers,* and my wife's *Ventricular Fibrillation and Sudden Cardiac Death* were almost ready in Russian. Great difficulties arose in trying to get these manuscripts out of the Soviet Union with us. Only the invaluable help of Prof. A.Y. Lerner, my friend and colleague from the Institute of Control Science (an outstanding scientist and a long-term refusenik at that time), solved this problem. He got consent from the Dutch Embassy in Moscow to send the microfilms of our manuscripts by diplomatic mail to Israel where my brother got them and forwarded them to the United States.

By the time I emigrated in 1987 and restarted my career at UCLA, hybrid computers were already obsolete in the United States. I put my manuscript in the trash with the exception of one chapter, which was published in 1988 in the *Transactions of the Society for Computer Simulation* [14]. My wife continued to work on her manuscript, translating it into English and editing it during the more than ten years that followed until it was published in 1999 [7].

Now

I: *You are at UCLA. You said you teach graduate courses and research computer simulation of complex dynamics of biological systems using massively parallel super computers. How does that compare to your early work?*

BK: I already mentioned that my experience with simulation using hybrid computer systems helped me to use massively parallel computers. Now I am fully occupied with the study of the mechanisms of heart fibrillation using computer simulation [9], [15].

This research is carried out in tight collaboration with Dr. J. Weiss, Dr. A. Garfinkel, and Dr. J. Goldhaber of the Cardiovascular Research Laboratory in the Division of Cardiology at UCLA, under the framework of an NIH grant.

Mathematical modeling of these processes and computer simulation are what is common with my early work. Certainly, I am no longer engaged in the development of any pure hardware and software design. I proposed and am teaching a new course for graduate students: "Introduction in Computational Cardiology." At UCLA, I have also taught a course for senior undergraduate students called "Real-Time Computation" for the past five years and have reconstructed the data communication system laboratory. From the beginning of my UCLA activity till now, I have had a team of several Ph.D. and senior undergraduate students working with me on my research projects. Four of them have successfully defended their Ph.D. dissertations.

I: *Do you have any long-term perspectives on the future of computing and computer simulation?*

BK: Yes, I have. It is connected with the problems described by so-called three-dimensional, diffusion-reaction systems. The diffusion-reaction systems are described by a special type of nonlinear parabolic partial differential equations. The propagation of the electrical wave along the heart represents the particular type of these systems. The simulation of wave propagation in the three-dimensional heart with up-to-date cell ionic model is very promising for cardiology—the creation of virtual heart—and at the same time requires tremendous increases in computational power. With the up-to-date parallel supercomputer, this is possible to achieve by the significant improvement of computational algorithms, for example to implement the adaptive time and space steps. The investigation of the effect of Markovian representation of gate processes in cell channels (with and without genetic mutation of channel proteins) on propagation of excitation along cardiac muscle, the effect of cell contraction on channels conductivity and excitation wave propagation are also a long-term focus for my research.

I: *Through all the years of your career, you seem to have managed to stay true to your calling. Is there any advice you have for individual researchers and the controls field in general?*

BK: I would like not to give any advice, but make two comments based on my personal experience:

- *For an individual researcher:* Always remember what was written on the grave of outstanding physicist of 19th century Ludwig Boltzmann: "There is nothing so practical as a good theory."
- *For the control field:* Some of the great physical systems to be studied as objects of control are the dynamic processes in the living organisms, especially under pathological conditions.

Closing Thoughts

This interview was generated from several months of e-mails with Prof. Kogan. Getting to know Boris has been a great experience for me. The impression that one gets from just a few e-mails and phone conversations is of an incredible individual who has a positive effect on everyone he interacts with. When expressing this feeling to people who have known Boris for years, they immediately concur and point out that it is simply the character of this individual. From those who remember his work in the Soviet Union to the medical researchers at UCLA who work with him today, from world-famous professors to his grandchildren who said all their friends in Los Angeles were jealous that they had such cool grandparents, from people who have been friends with him for years to those who have just met him—the impression upon interacting with Boris is of dealing with a giant of the field who is incredibly modest. Here is an individual who lived through some of the most turbulent times of the past century, much of it in a system that tended to break down the individual's core beliefs. Despite all this, he has persevered without bitterness or cynicism and has time for work, colleagues, and family. He is a role model for the rest of us.

Acknowledgments

This interview was done through e-mail over several months. The interview could not have happened without Prof. Kogan's patience and assistance in understanding the context of the material. I am also indebted to Dr. Valery Kanevsky of Agilent Laboratories, who not only translated the figure captions but also provided some extra insight into the historical characters, atmosphere, and times to help me frame my questions.

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What If

"If you want precision on a problem, you go to the digital. But if you want to explore, if you want to see what happens to the solution of an equation when you change constants, as you often do when you are designing something, the present-day differential analyzers are very convenient indeed."

—Vannevar Bush,
quoted in Susann Puchta, "On the role of mathematics and mathematical knowledge in the invention of Vannevar Bush's early analog computers,"
IEEE Annals of the History of Computing, vol. 18, no. 4, p. 56, 1996.

Stomach Intuition

Learning to use an analog computer forced the practitioner to cross the (unnecessary) boundaries between engineering disciplines; this may be its greatest virtue… There is no better way to develop a "gut feel" for the interplay between physics and mathematics than to experience such an interaction. The analog computer was a powerful interdisciplinary teaching tool; its obsolescence is mourned by many educators in a variety of fields.

—George F. Lang,
"Analog was not a computer trademark!"
Sound and Vibration, p. 23, August 2000.