Editorial and Historical Introduction

ARIFMOMETR[1]
An Archaeology of Computing in Russia

Georg Trogemann Alexander Nitussov Wolfgang Ernst

The genealogy of the computer and computing sciences as associated with names such as Charles Babbage, Alan Turing, Norbert Wiener, Heinz v. Foerster, Claude Shannon and John v. Neumann has been the object of an impressive number of media-archaeological publications in the German-speaking and Anglo-American areas, but in general the historiography of computing is - even a decennium after the fall of the Iron Curtain - still blind in respect to Eastern Europe. This is why the combined research and publication project *Arifmometr*, carried out by the Academy of Media Arts in Cologne in co-operation with institutions in the former Soviet Union, tries to evaluate the role which Russia played in contributing to the development of the medium computer in complementary or alternative ways on both technical and cultural horizons. Furthermore, in reconstructing the Russian case, emphasis has been put on the relationship between mathematical and cybernetic thinking on the one hand, and social, economical and political models on the other.

The Historiography of Computing and Archival Evidence

The introduction to one of the few articles in English which have previously been published on Soviet computer archaeology, prompted by the International Research Conference on the History of Computing at Los Alamos (New Mexico) in June 1976, is characteristic for the nature of research: ” Based on publications, personal reminiscences and the author´s own archives, this historical paper attempts to analyze the first 15 years of the formation and development of computer programming in the USSR.”[2] What is missing here is the level of institutional archival evidence. The documentary archive of the development of computing in Russia thus remained a kind of *black box* for Western research. This Pandora´s Box was only opened for a few moment when, for example, Lebedev brought a four language brochure on the electronic calculator BESM-1 into circulation at the international computing conference at Darmstadt (Germany) in 1955. While the Soviet variant in the development of computing was marked by the separation between universal (”multi-purpose”) and military (”special purpose”) applications, it was not questions of artificial intelligence which fostered research, but rather the necessities of military precision in ballistic calculations and their counter-check which led to designing machines which could reliably function even under extreme conditions[3]. This division is reflected by the nature of archival evidence itself, with published technical reports, accessible in the Central State Library (the former Lenin Library) in Moscow on the one hand, and documents from the secret development areas on the other.

An additional difficulty in re-writing the history of computing in Russia

1 Taking the specificity of Russian phonetics into account, the editors want to remind the reader of the difference in the spelling of names with a common origin. For an example,the calculating machine “Arithmometer” whichwas demonstratedby Charles Xavier Thomas in Paris in 1821 turned into “Arifmometr” in St. Petersburg.

2 Andrei P. Ershov and Mikhail R. Shura-Bura, The Early Development of Programming in the USSR, in: Nicholas C. Metropolis (ed.), A History of Computing in the twentieth century, New York (Acad. Pr.) 1980, 137-196 (137).

3 This view was expressed by Professor Khetagurov during his lecture at the conference Gute und böse Maschinen [Good and Evil Machines] at the Academy of Media Arts, Cologne, in January 1997. Also in his article ”The art of reliable system creation”, [transl. A. N.] in: Lab. Jahrhbuch 1996/97 für Künste und Apparate, ed. Academy of Media Arts in Cologne (with the friends of the Academy of Media Arts), Cologne (Walther König) 1997, 334-342.

results from the fact that, in part, the transmission of knowledge did not always take place in written form; Lebedev, the protagonist of electronically programmable computers in the early 1950s, for example, "did not like writing" (Khetagurov). And even if the basic texts were published, they were rarely accessible in the English language[4]. This is true for both the Western and the Eastern perspective:

> We have worked primarily from publications, relying less heavily on archival materials. However, we have used our personal archives and our own recollections when it seemed appropriate. Some original publications, especially foreign ones, were unavailable to us[5].

From the perspective of the Western hemisphere, there has always been an obscured idea of what kind of technical developments took place in the East. Already Johann Paul Bischoff´s Attempt of a History of Calculating Machines in 1804 only occasionally touches upon abacuses and "similar tools of the Russians"[6]. This silence can only be matched by an archaeology of Russian computational thinking, until the final convergence of Eastern and Western standards of program-directed media. Since the early 1970s, IBM-compatible machines were being manufactured in the USSR, and since the early 1980s both in the East and in the West the overall development of computing is no longer exclusively dominated by primarily scientific ideas and military strategies but by commercial interests as well. Until that point, the Russian versions of computing had been directed by the priority of theoretical basic research on the one hand (with direct supply from the state for research institutions, independent from the needs of a non-existent economic market) and by special developments for military purposes on the other. The production logic of the capitalist market which had led to the assembly line and to the standardization as well as modularization of machine parts in America (making possible a switching between the production of machine guns and typewriters, for example) clearly separated the development of Soviet computing from its equivalent in the West. It is interesting to notice that the higher quality of the mass products was indubitably a serious advantage of the American industry. At the same time, the pressure of standards and a tendency to solve problems with (traditional) standard methods (and appropriate investments) sometimes limited the possibilities of the produced systems in comparison with "untraditional" Russian machines.

Notable for this difference is the *special purpose computer* in Russia, manifesting the interest in specific military-orientated hardware (engineering as opposed to mathematics), with the accent on "independence of the precision of their calculations from the precision with which they were manufactured" (Khetagurov). This priority is mirrored in the architecture of data storage as well:

> The design of many Soviet special computers did not exactly follow von Neuman´s principles. In many machines, the memory for statements and the memory for numbers were separated and worked independently. Such a structure increased the performance and eliminated possible accidents with programs (including penetration by viruses). It was also an additional protection from undesirable human actions[7].

The irreducible asymmetry between a time- *versus* storage-orientated economy of speed in computing is linked to the most basic level of programming aesthetics. Though to write a program in the programming language is easier, it can not be used directly in a computer since it must first be translated into machine codes. After the translation, the program written in machine languages again becomes 3-6 times longer and needs 3-6 times more memory. As a result, the time saved in preparing the program had to be paid with increased memory, that is by a still larger amount of hardware. This was

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4 For example Andrei N. Kolmogorov, Logical Basis for Information Theory and Probability Theory, in: IEEE Transactions on Information Theory, vol. IT-14, no. 5, September 1968, 662-664.

5 Ershov / Shura-Bura 1980: 139.

6 Johann Paul Bischoff, Versuch einer Geschichte der Rechenmaschine, Ansbach 1804; here quoted after the new edition by Stephan Weiß, Munich (Systema) 1990, 40. Even this occasional remark on early computing in Russia is nothing but an indirect quotation from Kaestner´s History of Mathematics (part I, page 43) who himself refers to Peter von Hefer´s Journey to Russia.

7 Y. A. Khetagurov, Some notices on the development of special computers in Russia (in the present volume).

scarcely acceptable especially in mobile computer systems. Thus, it became a sort of a dead-loop.

With the electronic calculator MESM in 1950, Sergej Lebedev developed a structure analogous to the von-Neumann-architecture of computers (with the principle of storing both data and programs in the same memory) rather independently of knowledge about parallel performances in the West[8]. Still, computing in the USSR was all but a state priority for a long time.

It was not the government's initiative to establish a new computing industry to assist scientific (defence) research but primarily of progressive scientists like Lavrentyev, who needed new technologies for their projects. Stalin paid attention to this "post factum", in the 1950[9].

The term "archaeology of computing" in the present context is being used - in accordance with Michel Foucault´s *Archaeology of Knowledge* (Paris 1969) - both metaphorically (referring to the discursive dispositives of mathematical thinking) and literally (referring to the kind of evidence which can be discovered in the archive). The opening of several formerly secret Russian archives as a consequence of the Soviet *perestroika* first and then as part of the democratic reconfiguration of Russia made it possible for the first time to investigate documentary evidence, that is monuments of the genealogy of computing in the former Soviet Union. What remains to be cleared is whether the previous silence on the history of computing in Russia results from the archive itself (as lack of evidence) or from a kind of silencing which is everything but occasional, but rather a function of historical, sociological and technical contexts.

Still, this situation, which remains unclear, offers a unique chance: the documents which remain to be discovered still retain a kind of archaeological status, since they have not already been absorbed into a previously conceived narrative of computational thinking and practice in Russia. This results in a difficulty for both research and presenting its results: (how) is it possible to write the genealogy of computing in Russia not as a conventional history but in the form of a genuine media archaeology? The structure of the archive itself here determines the forms of administrating this specific memory, and the archaeographical approach tries to resist the temptation of creating effects of consistence and wholeness by means of a linguistically closed presentation. On the contrary, it reveals the ruptures, lacks and incisions, the inconsistencies in this effort to reconstruct the genealogy of computing in Russia. That is why this publication rather resembles an effort to structure a textual data bank in synchronous ways, spatializing archival time, alternative to traditional histories of computing as known for the Western case.

While historical research on the origin(s) of electronic computing soon leads to adverbial pointers like "already", "for the first time", creating a literary field of competition in historical priorities, the archive rather offers a labyrinth of knowledge which to navigate is still a cultural technique to be learned (following Walter Benjamin´s claim in his *Berliner Kindheit*). "Often the (almost) simultaneous but independent creation of the principally new technical facility in different countries (places) is a natural event"[10]; that is why a presentation in the form of causal chains is less plausible than a topographical structure, a kind of mapping of the evidence rather than subjecting it to forms of linear computer historiography. The reader should, therefore, not look for a history of computing in Russia, but rather is invited for a stroll through a fragmented landscape, adorned with monumental machines and isolated biographies. The interconnections here, diffe-

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8 Characteristic of the tricky communication on computing between East and West in these years is the way which created Bashir Iskanderovich Ramejev´s interest in electronic computing: "In 1947 listening to a BBC broadcast (what could have had a dangerous consequence) Ramejev learned about the first American electronic computer" (as quoted from B. N. Malinovskiy´s article on Ramejev, in this volume).

9 B. N. Malinovskiy on Sergey Alekseevich Lebedev, in the present volume.

10 Igor A. Apokin, Electronic computers, in the present volume.

rent from the logic of electriconic circuits, will always be conjectural; this is why the present publication is not a technical, but a techno-cultural introduction to the subject.

The Complex Historical Study and the Problems of Mutual Understanding

An adequate understanding of the processes, events and interrelations is necessary as background for the thorough evaluation of the studied facts. This is another problem to be addressed. It acquires a decisive importance in the light of foreign issues, since not only the evaluation of new material needs a new system of criteria but even the new information's incorrect perception itself might cause errors that would deform the whole structure created by the researcher. Thus, according to the traditions and values of his own origin, he might totally neglect some originally significant details, and vice versa. The creation of a new evaluational system even for limited scientific purposes is an arduous process; adhering to the accustomed criteria and to the subconscious tendency of their extrapolations on new information is quite human. Such examples are numerous. For an instance, the famous physicist and mineralogist Pallas, who worked in Russia in the 1767-1804 and made several important discoveries there (e.g. studied the nature of space meteorites), also noticed the low cultural level of its population and the complete Westernization of its educated circles, seemingly separated from their national background. Later, he wrote that, "in this country neither poets nor artists could ever appear."[11] No comment is necessary.

In 1924, when the USSR was still in post-war depression and its state and future looked quite pessimistic, A. Gastev and N. Bernshtein were invited to the Prague International Conference on the Scientific Organization of Labour. Unexpectedly for the organization committee, this conference almost entirely turned into a demonstration of the Moscow physiologists' achievements (V.E. Demidov). The destruction of the European part of Russia and the constant post-war shortage of the most important items (food, etc.) brought numerous Western experts to the conclusion that the Soviet economy's restoration would take several decades. In fact, the average standard of living already surpassed the pre-war mark in the mid-1950s and the science was incomparably advanced.

It is characteristic for the social structure of our time to have a broad distribution of personal/professional functions. This distribution focuses the intellectual efforts of a person on a limited set of subjects, absorbing most of his energy and noticeably deactivating his interest to other issues. Thus, the individual's dependence on this structure increases and he mainly accepts the standard criteria adopted by it. His own perception loses flexibility. Normally, the mathematical, technical, or other "professional" descriptions are clear for all concerned specialists, regardless of their social or national origin. Sometimes, they do not even require detailed linguistic translation. However, their historical, socialor simplylocalcontexts often cause very different understandings,especially when theyare demonstrated inplaceswithdifferentculturalorhistoricalbackgrounds.

I. Polzunov, a provincial inventor from the Urals, built the twin cylinder steam engine of his own design twenty years before J. Watt. As Polsunov's machine was mounted at a metallurgical factory and proved to be efficient in regular operation, the mechanic Falk and the metallurgist Pallas from the St. Petersburg Academy were dispatched to inspect it. Falk (who came from Europe not long before) noticed that some parts of it (probably packings and supports) were made of wood and bark and, despite of its reliable operation, described the machine something like “The fantasy of an ignorant barbarian"[12]. Falk obviously was dogmatically accustomed to some different standards and even did not try to prove the technical properties of other, unusual for him materials[13].

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11 V.V. Danilevskiy. RusskayaTehnika [Russian Engineering]. Leningradskoye Gazetno-Zhurnal'noye Izdatel'stvo, 1948, 548 p.

12 V.V. Danilevskiy, 1948.

13 It probably seemed a "lower level" for him. However, such materials were successfully used for technical purposes. Even Thomas Edison made the first filaments for his electric bulbs from charred bamboo pieces.

If we do not understand the facts and related circumstances in the same way as in the place of their origin, the risk of being misled in our subsequent (historical) conclusions significantly increases. Besides, the correctness of our judgements always depends on our proper knowledge of the subject - that is, on the amount of authentic information. Unfortunately, the accessibility of information turned into one of the biggest problems, as the cultural communication between East and West were complicated first with the Russian Socialist Revolution, followed by severe ideological and propagandistic war, and later the Cold War with its "Iron Curtain", which brought them to a minimum[14]. Despite of the revival during the early 1960s, they were far from really normal until the late 1980s, regardless of the noticeable liberalisation in the 1970s. Looking at the modern information landscape, one can easily notice that in spite of the reasonable progress of the last decade, the real knowledge about "the other side's" scientific development is still insufficient. The defence area, and some others, were not popularised even in their own countries for various reasons. As such, they still remain especially "mysterious" even today.

The "famous difficulty" in creating criteria for Russian scientific (or other) history consists in its specific features, hidden under its basically European nature and appearance. In fact, these distinctions would hardly be clear without considering their formative factors. In Western Europe, which is more advanced, urbanized and compact, the population is dense. Communications and infrastructure are well developed. Together with rather limited natural resources, these factors historically created traditions of stable, rhythmical production, market competition and the subsequent maximization of production quality. Quite naturally, this stimulated the distribution and specification of labour functions and the perfection of manufacturing technologies.

Similar traditions appeared in Russia centuries later. Its historically unstable life, rich resources, uneven climate, incomparably bigger distances and insufficient infrastructure stimulated an increasingly creative approach, universal but individual; rather "adocratic" than structuralized and impulsive rather than rhythmical. Solving an entire complex of problems through the concentrated efforts of a single team and often mainly (or only) with local means was more typical. This style usually made possible advanced pioneer or single projects but often failed when long-term, routine, high quality production was needed, especially when it had to be supported by other branches. In reality, "unevenness" could be a key word in the historical study of Russia. The successful advances of Soviet computer design of the 1950-80s were left without adequate support from the high-tech and electronic industry in the 1960-80s, and were plagued by the lack of the appropriate hard- and software state standards in the 1960-70s. Without a doubt, this is a sad but adequate example of such "unevenness".

Specific features were naturally formed by the specific historical conditions. E.g. the unstable and uncertain life decreased the significance of material items and shifted the priorities to spiritual and intellectual issues, which were harder to create but easier to preserve. Besides, they had the obvious advantage of being always "ready for

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14 The lack of the proper information about the Soviet computing in the West cannot only be explained by the ban imposed by special services or with its insufficient amount and "lower quality" in the USSR itself. Though the restrictions really existed for secrecy reasons, sometimes in rather ridiculous forms, it is hard to believe that nobody in the West had any access to the thousands of publications on various computer subjects that always filled Russian public libraries and countless book-shops, or to the machines that could be found in every open (not secret) research institute or university. Some official information exchange existed already in the mid-1950s when S.A. Lebedev reported on his machines at the conference in Darmstadt. At the same time, the European nuclear physics research centre CERN established stable partnership with its Russian analogue JINR (see V.P. Shirikov. Scientific Computer Networks). In the 1960s, the reduction of political tension between the West and East stimulated the official extension of the scientific exchange. The first Soviet joint venture, established with the West-German company Siemens in the late 1960s in Moscow, participated in computer projects (see E.N. Filinov). In 1969-70s, attempts were made to co-operate with SIEMENS and the British company ICLin order to create the "Euro-computer". Their experts visited Moscow and studied the possibilities of the USSR's computer production (see B.N. Malinovskiy). The Italian company Olivetti also was present in the USSR.

action". The increased value of these subjects naturally increased public respect to those who possessed such qualities and were able to find a proper solution, especially in a sudden critical situation. The lack of personal initiative, regardless of the individual's official position, always was considered a negative personal characteristic, no matter how tight the executive discipline. The synthesis of Cold War ideology and the lack of proper information caused an unawareness of such "Russian specifics", leading to rather misguiding ideological stereotypes. Thus, the famous official attacks on cybernetics during the 1950s often evoke the idea of a total ban on digital computers. However, in reality, according to official Soviet practice, these two areas had nothing in common. The state always supported the development of digital electronic computers as advanced mathematical calculating machinery. It is also believed that the creation of the first electronic computers was mainly made possible through technical information of Western origin, since the design of early Soviet machines followed in analogy to von Neumann's principles. In fact, the Western computer producers did not reveal technological details, and the information released sporadically did not exceed the common limits of commercial advertising. Of course, this was of little help to the designers, especially if they had no supplementary information. The supposed information supply by the Soviet secret services also did not improve the situation. The first computer projects were merely considered as auxiliary experiments and were not performed by military institutions. Therefore, they could not be provided, even indirectly, with secret information. A similar opinion exists regarding the direct copying of American computers in the 1970-80s. However, such copying would have been equally impossible, even for the simple reason of the Soviet Union's inferior technological level. Historically, many of its scientific discoveries and technical inventions, including computers, originated from the military field or were connected with it. This seemed to signify the general Russian military orientation. In fact, this military weighting only meant a certain disproportion in its internal development. As early as two centuries ago, Imperial Russia had to maintain military power on a level comparable to the industrialized West, in spite of the predominantly agricultural economy. This maintenance of power was seen as a necessity. However, its civil industry was lagging behind until nearly the 1960s. Therefore, its civil development often had to be supported by the more advanced military one, which caused the mentioned illusion. While this was altogether usual for Russia, it was uncommon in Western practice. The famous constant addressing or even "monitoring" of foreign experience and many other traditions also can be misunderstood in a somewhat similar way.

In reality, the subject of the present publication - Russian computing - is still a ”terra incognita” for almost everyone in Western Europe and also for many in Russia itself. Some amount of research on early computation devices and digital computers was performed already in the 1960-70s. However, the results were rather fragmentary and limited to the nineteenth century inventions and some civil hardware. Besides, the books were published in insufficient quantities.

There is probably no great exaggeration in saying that the young computer sciences have only very recently reached the threshold where the whole complex of accumulated theoretical material, practical experience and scientific traditions proved sufficient for initiating some sort of retrospective historical analysis. Luckily, this development chronologically coincided with the social changes of the last years, which simplified access to the Russian archives and other information sources.

Since computer subjects are not enclosed within their own habitat but are inseparable from electronics, information theory, computational mathematics, cybernetics and even philosophy and psychology, the amount of information to be studied, properly systematized and presented in some scientific and yet more popular way is unimaginably huge. This "global task" is complicated by the purely ”technical” problems of finding historical materials (documents), since reliable information about their ”availability and location” is scarce. The work of such impressive dimensions is hardly possible without a significant amount of time and naturally appropriate investments. However, both were not easily obtainable under the crisis conditions in the Russia of the 1990s. All this hampers both the progress of Russian computer historiography and the dissemination of its results. Nevertheless, some steps have already been made by some of its computer pioneers themselves[15], who wrote on significant scientific discoveries and episodes. However they are often dedicated to specific limited subjects. In general the agenda of such historical research is rather disputable everywhere. Thus, some of them tend to emphasise the importance of human relations or of social context in some discoveries, especially when they concern the problems of early Soviet cybernetics, while some others look more like catalogues or illustrated inventories of old hardware stores. Most of their authors are computer experts themselves, sophisticated professionals who often provide exciting material, although they seldom have much experience in historiography or didactics. Quite logically, historical studies at European universities often concentrate on their own achievements. The computer museums also do not possess much information about the East.

The present edition is the first attempt ever made to demonstrate the full-scale picture of the chronological development of Russian computing, both in its scientific and cultural context. The following historical introduction is intended to clarify possible sources of confusion and to assist the reader in making his or her own judgements. Simultaneously, it offers general information about both the country and its science.

Historical Elements which lead to Computation and Computers in Russia

Having appeared on the map in 862 AD as a "meeting" -or rather a "smelting"- point of several European peoples[16], Russia developed as a Christian Orthodox country under a strong cultural and religious Byzantine influence; with the royal family established by the Vikings, many of whom were assimilated. Situated on vast, mainly wild territory, very rich in natural resources, as the "frontier of Europe" bordering on Asia, it acquired many features of a pioneer country. They were noticeably distinct from those of the West. During the following centuries it constantly absorbed numerous Europeans, and from the 17th century those were predominantly Germans. As a multinational young country always needs a common consolidating ideology, this issue acquired a special importance, which subsequently turned into a stable feature. Being European, although the Orthodox country Russia traditionally maintained close cultural connections with the Roman Catholic West, and the interest for its novelties was always high. This interest persisted in all historical periods. Even during the Cold-War, the USSR's public was always informed about scientific or other events in the West. Though social, political and cultural issues were often commented from the ideological positions, they were seldom ignored by the Soviet mass media, at least after the mid-1950s. Besides, the personal interest was always very active. Also the multi-national origin of the country left little room for racism or any serious xenophobia but created what might be termed “national flexibility”. In general, this tendency greatly simplified the adoption of progressive ideas and novelties, regardless of their origin. Naturally, due to geographical differences, such novelties were analysed for the possibility of their local practical use, what formed a tradition of a critical analytical approach to novelties in general.

Although any internal ethnic conflicts were never known the political rivalry between Russian cities-principalities remained fierce until as late as the 16th century[17]when the centralised state under Moscow’s supremacy was finally established. Coinciding with the two centuries of the Mongol invasion (13th -15th) this confrontation

15 Conference reports, a number of articles and two books have been already published, B.N. Malinovskiy. Istoriya Vychislitel'noy Tehniki v Litsah [The History of Computing in Personalities], Kiev, KIT, 1994 and D.A. Pospelov, Ya.I. Fet, [Essays on the History of Computer Science in Russia], Novosibirsk, 1998. The earlier book on calculating machinery I.A.Apokin, L.M. Maystrov. Development of Computing Machinery. Moscow, 1973. contains descriptions of several Soviet electronic computers.

16 Mainly Slavs, Finns, Lithuanians and Vikings.

essentially hampered general development.

The Greek alphabet, slightly improved by the two Bulgarian brothers (of a Byzantine official's family), the monks Kirill and Mefodiy (hence Cyrillic alphabet), and Greek numeration[18] were among the Christian cultural attributes adopted by Russia. The complexity of Greek numeration was not decisive, the usual calculations served simple practical needs, such as inventories or building measurements. Simple fractions were probably also well known, since not only the basic coins (roubles) but also their halves, quarters etc. were widely used. Other means of payment, including various foreign currencies[19] were also used, so both their exchange and the foreign trade in general naturally needed arithmetic calculations. The oldest known Russian mathematical work was composed by Kirik, an educated monk from the St. Antonius monastery of Novgorod in 1134. It was dedicated to arithmetical chronological calculations, consisted of 19 parts and basically repeated everything that was written in Greek religious books about the calendar. Kirik could calculate the yearly dates of the Easter celebration, operating with eight decimal place numbers and demonstrating the addition and multiplication of integers. He also calculated a geometric progression derived from the division of the 12 hour day by hours and the hours by "fractional hours". Its members were fractions of one divided by 12, 60, 300 etc., up to 937,500, where he stopped with the commentary that "there can be no greater division".

Foreign relations and trade were always welcome. However, with low population density and complicated communications, the satisfaction of daily needs with native efforts and local means was preferable. The rich local resources provided everything necessary for independent life. This did not stimulate the market's growth and stability. More or less regular production only existed in agriculture, mainly on a domestic basis. However, even here the notion "regular" is very relative, since Russia's continental climatic conditions are more hostile than in Central Europe and the productive period is limited. The maximum concentration of efforts on field work in spring and during the autumn harvest became a stable tradition for many centuries to come. The long winter interrupted all work except for small domestic occupations and provided plenty of time for religious rites, cultural activities and local crafts, which often acquired features of folk art (V.O. Klyuchevskiy). The rhythmic regular manufacturing started in Russia much later then in the West. At the same time, all intellectual and physical efforts and local resources could be rapidly mobilized for the solution of urgent local problems. In such periods, work was unbelievably intensive. Such a life style also stimulated personal initiative and inventiveness (V.O. Klyuchevskiy). Until the 13th century the general level of development in Russia was comparable with the West but the two following centuries of Mongol invasion brought large-scale destruction, caused a long lasting depression and largely interrupted foreign relations. Although some trade contacts existed and included some arithmetical calculations[20], the education was in a state of crisis, and, for an example, when the calendar composed by Kirik came to its end, there was nobody in the whole

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17 The differences between its principal parts were essential. While the North-West (Pskov and Nowgorod with their highly developed democratic institutions) bordering on the Scandinavia and Baltic, until the 15th century was basically "Western" and "pro Baltic/Lituanian", the South which had neither Finnish nor Baltic population (Kiev was the first Russian capital) was directly connected with Byzantine, due to both the traditional Greek relations and the river trade way from Birka and Uppsala to Konstantinopolis, via Novgorod and Kiev. Moscow appeared much later (12th century) in relatively remote area and developed more individual features.

18 Greek numeration also used letters for numbers (e.g. a=1, b=2, etc. up to 10, then each following letter stood for tens, e.g. p=10, r=20 ..., further on the same characters were provided with additional symbols and used for thousands, tens of thousands etc.). This system was acceptable for recording numbers (results) but rather uncomfortable for any complicated calculations. B.V. Gnedenko. Ocherki po istorii matematiki v Rossii [Essays on the History of Mathematics in Russia]. Moscow, 1946.

19 Not only European coins were in use. Due to the Volga explorations, Viking-Russian merchants had also visited lands to the south of the Caspian sea as early as the 9th and 10th centuries. Remnants of the Viking settlements were discovered in northern Iran. Coins from Iran, Damascus and other Eastern places were found in excavations of ancient Russian towns.

20 The number of trade agreements between Novgorod and German (Hansa) towns, signed in the 1270s, proves that some

country who could make more calculations to continue the calendar[21]. However some elements of the Eastern culture would be brought by the Mongols, among them the Chinese abacus "Suan-Pan" (a probable initial model for the Russian abacus, "schoty") though many historians insist that "Schoty" is a local invention, since the differences are too essential (e.g. the stones of Russian Schoty move horizontal while the Suan-Pan is vertical). After the liberation, Russia did everything to strengthen its Christian values and to intensively regain its European relations[22], this time as a centralised self-oriented state. The vitally important ability of efficiently achieving goals with minimal means under an inferior infrastructure developed in that time of struggle and survival. It became especially productive in combination with personal inventiveness and initiative. This traditional ability could be traced even in the creation of the first Soviet computers under the conditions of post-war destruction and universal shortages.

Russia's first institution of higher education, the Kiev Religious Academy, was established in the 17th century. Basically, it served the needs of the Orthodox church although the educational program and some teachers were taken from the Jesuits. The Slavic-Greek-Latin Academy, a similar institute, was established in Moscow in 1687. It was headed by the Likhudos brothers, the brilliant scientists of Russian-Greek origin, who graduated from the Padova university. Leontiy F. Magnitskiy (1669-1739), the outstanding Russian mathematician, author of "Arithmetic", the famous first text-book on mathematics, was among its graduates. This book, printed in 1703, became the standard work for many following years; besides arithmetic, it contained material on algebra, geometry, trigonometry, meteorology, astronomy and navigation. In his works, Magnitskiy only used decimal numeration. At the Academy, he studied foreign languages, studying mathematics independently, mainly relying upon European scientific literature. However, these institutes themselves did not practically contribute to mathematical education. The importance of this became clear even for the merchants whose arithmetic ignorance caused big loses in foreign trading. The general educational system was still in a nearly catastrophic state. In the 18th century, Tsar Peter I created a real revolution[23]. He himself started with intensive learning in Germany and Holland, focusing especially on ship-building, navigation as well as medicine and cultural novelties. He was the first Russian ruler to introduce obligatory education for all social groups; many young people were also sent to learn in Europe. He established a special school for navigation and mathematics in Moscow and in 1701 invited Professor Farwarson of Great Britain's Aberdeen University to head it. Farwarson energetically introduced many mathematical subjects and among other things, also edited Euclid's books for Russian publication himself. In 1715, the St. Petersburg Maritime Academy was established as the affiliate of this school. In the same year, Peter dispatched two of its graduates to each administrative area to found 48 local mathematical schools called "Numerical Schools", (existed until 1744) which later were combined with the so-called "Garrison Schools"[24], established in 1737.

The accelerated economic and cultural development and its Westernization

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mathematics still existed. These agreements contained some practical arithmetic (e.g. calculation of weights), and the exchange rates between the Russian and German units. (For an example, "The guest /=foreign merchant/ should pay 9 squirrel skins for weighing each pack. The "pack" should contain the weight of 8 Livonian/German pounds") (B.V. Gnedenko).

21 For this reason, Novgorod bishop Gennadiy Gonzov initiated a special expedition to Rome in 1470 for either the source tables or some ready calendar. Bishop Gonzov was an educated man and after this expedition himself calculated the Easter calendar for the next 70 years, although he was not quite sure of its correctness (B. Gnedenko).

22 The Byzantine state itself was ruined by the Ottoman empire and the marriage of the great prince Ivan III of Russia with the last Byzantine princess Sophia in 1465 (who resided in Rome), transferred the centre of Orthodox religion to Moscow. Sophia also brought with herself a rich library and introduced in Russia the stable Italian architectural traditions.

23 In the 17th-18th centuries Russia made efforts to re-establish its Baltic/European connections, however the direct sea communications were closed by the Sweden. The East Prussia experienced similar difficulties and sought an alliance. Supported by the coincidence of interests young tsar Peter started preparations for "breaking the window into Europe" (his own words).

24 According to the Peter's order, each military garrison opened a primary Garrison School (with officers as teachers).

turned Russia into a European empire. The basis for such status already existed "de facto" due to its vast territory and natural riches. For the 18th century empire, the need for a strong modern army, at least for defensive purposes, was inevitable. It is quite evident that in the huge purely agricultural country with its inferior infra-structure and its newly forming administration, the army was one of the best organized and the most functional institutions. Able to co-ordinate action on a broad scale quickly, it could not only be used for purely military purposes but could also efficiently support various civil programs. This remained an important tradition until our time.

The industrial development stimulated by the growth of army and navy still increased the need for educated specialists. On January 24th, 1724, the Russian Academy of Sciences was established on the directive of Peter, who himself was elected as a member of honour of the Paris Academy. He was assisted in its organisation by the famous German mathematician and philosopher Wolf, who recommended younger mathematicians such as Professor Hermann (a student of James Bernully), Nicolaus and Daniel Bernully (the sons of famous Johann Bernully) and Christian Goldbach. In 1727, they were joined by the young Leonard Euler (1707-1783), later a world famous mathematician, who remained at the St. Petersburg academy until his death. During the Academy's first years, there were no Russian students ready to learn, so they also were invited from Europe[25]. The new academicians founded the first scientific journal called "The Commentaries of the St. Petersburg Academy"[26]. This publication was successful; Euler published his articles in each issue[27]. The third number contained Bernully's famous paper, "On the Oscillations of String", where a solution was demonstrated with a trigonometrical array for the first time. With Peter's early death in 1725, official interest in science declined. From the 1740s onward, it was even viewed with open suspect[28]. Euler left for Berlin and returned to Russia in 1766[29], when the young Russian empress Ekaterina II (born Sophia Frederika Augusta von Anhalt-Zerbst, ruled from 1762 till 1796), whose dream was to bring the glamour of European culture into Russia, revived the "epoch of enlightenment" which awoke many talents. Her close friend princess Ekaterina Dashkova was the president of the St. Petersburg and Russian academies for many years. Both Ekaterina II and Dashkova noticeably contributed to the development of Russian literature. It was during this period that the first known Russian calculating devices were created. Before 1773, Jevno Jakobson, a goldsmith and clock-maker from Nesvizh[30], made an advanced arithmetic machine. Terentiy Voloskov (1729-1806) a mechanician from Rzhev (near Moscow) made a very complicated astronomic long case clock, which automatically calculated years, months, days, hours, etc. It displayed the phases of the moon, the current positions of the moon and sun and the corresponding Zodiac constellations. It also featured a mechanical horizon line coloured in blue, which stretched and contracted proportionally to the current day's length. A special disk also displayed the leap-years, which were counted for general higher precision. The clock also

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This proved to be efficient since they were quickly organised. Also the resistance of many conservative parents had to be overcome, and the soldiers sometimes had to bring the children to classes by force.

25 In the beginning, there were only 8 students and 17 professors. Since the Academy's regulations demanded the students to outnumber the teachers, the professors also had to attend each other's lectures (B.V. Gnedenko).

26 In original, "Commentarii Academiae Scientiarvm Imperialis Petropolitane".<Ibid.>

27 Euler's scientific contribution and heritage is huge. In our time, 865 of his works are known. Of them, there are 43 volumes of only the most extensive articles. For an example, Euler established the famous "Theory of Lunar Motion", calculating and composing navigation tables based on lunar mechanics. The British parliament awarded him a prize of 300 pounds for this work in 1765. He also created a so-called "variation calculus" and essentially contributed to the theory of numbers. Unfortunately, eight of his principal pupils, including his son A. Euler did not make any significant scientific discoveries. However, all of them were excellent teachers.

28 For an instance, the Russian historian Müller who wrote on the Mongol invasion was accused of "insulting the Emperor's Majesty" (Ibid).

29 Most of the time abroad, he continued to receive a salary from the St. Petersburg academy.

30 See the article by I. Apokin in the present volume.

performed all calculations for the Church calendar (indicta, epacta, vurzeletto, etc.), producing dates for Easter and other transferring festive days. The complexity of such calculation is evident; for an example, Gauss implemented special mathematical methods for the same purpose[31]. Euler enjoyed this creative atmosphere and maintained personal relations with some inventors. He participated in the projects of the outstanding mechanician Ivan Kulibin (1735-1818), the curator of the St. Petersburg academy laboratories since 1769. Kulibin was engaged in the development of scientific measuring instrumentation. Most probably, Kulibin was the first in Russia to formulate the method of analog modelling and widely implement it in applied mechanics. He always made exact scale models of his mechanisms and tested them with proportional loads. Among his numerous inventions[32] Kulibin made a model, about 25 meters long, of a single arc truss bridge to be built over the river Neva in St. Petersburg (300 m). Euler proved the reliability of Kulibin's analog method with his own mathematical calculations and found that, in reality, the construction was even stronger than expected. As the testing weight of many tons[33] was perfectly carried by the model, the delighted Euler moved all members of the commission onto it, then climbed up himself and jumped up and down. As a daring inventor, Kulibin was not confused in case the theoretical basis for his inventions were absent. He would rely on empirical foundations and his own professional intuition. Back then, it was typical for many inventors. The independent thinking, initiative and the habit of combining new ideas with original methods of problem solving gave rise to numerous inventions. Many of these were made in remote provincial places. Unfortunately, although many of them were equal to the best of Europe, they were not supported by the industry, which was only then being formed, or by the conservative administration. The intensive foreign communications of the time had one negative aspect: for the Russian aristocracy, everything Russian became hopelessly provincial and most often Western novelties were preferred dogmatically. Only few approached them with traditional ironical thoroughness. Russian own achievements were often met with a great deal of scepticism. The aristocracy's ignorance hampered the state's development. This was so obvious that new regulations in 1803 made higher education obligatory for joining the state service[34]. A law of 1809 introduced promotion examinations. Universities were also established, although special faculties for physics and mathematics were only introduced in 1804, under the influence of the French Revolution, "which demonstrated the importance of people with mathematical education" (B.V. Gnedenko).

Kazan University was established in 1804. The mathematics Professors Bartels, Broner, Renner and Littroff (luckily very good teachers) arrived there from Germany. In the beginning the atmosphere wasquite favourable and the studentswere fullof enthusiasm[35]. For many years, Martin Bartels (1769-1833) supported Nikolay Lobachevskiy (1792-1856), his extraordinary student, one of the greatest Russian mathematicians. Once, he even saved Lobachevskiy from very serious trouble, since he was accused of the "signs of blasphemy and other false ideas". In 1811, on his receiving Master's degree in mathematics Bartels recommended him to the university rector as so successful in science that "he would even be an excellent student in every German university". Under Bartels' gui-

31 It could be characterised as the first "special" calculator (mechanical): In, V.V. Danilevskiy. Russkaya Tehnika [Russian Engineering]. Leningradskoye Gazetno-Zhurnal'noye Izdatel'stvo, 1948, p. 548.

32 Kulibin created a miniature automatic clock with the size and shape of a goose egg. It played various melodies once an hour and made theatre performances with numerous actors.

33 In the source for the earlier Russian inventions (V. Blokhovitinov et. al. Rasskazy o Russkom Pervenstve [The Stories About Russian Pioneer Achievements]. Molodaya Gvardiya, Moscow, 1950.) the weight is given as 3,870 old Russian units (pud=16 kg).

34 It was the beginning of the reign of the liberal and well educated Emperor Alexander I, after the death of his father Pavel I (the only child of Ekaterina II). Pavel I himself established a police dictatorship and spent a great deal of time with rearranging Russian army on the Prussian model.

35 E.V. Vinberg. Nikolay Lobachevskiy: On the occasion of his 200th anniversary. In: European Mathematical Society Newsletter. 6 1992, p. 8-9.

dance[36], Lobachebvskiy began his scientific work. Unfortunately, its stable progress was interrupted in 1819 until 1826. In his official report to the government, the new university inspector M.L. Magnitskiy accused the administration of wasting the state's finances and indicted the teachers of using atheist methods[37] He even suggested the physical destruction of the university building. This beginning reaction forced most professors to leave, and practically all sciences were replaced with theology and other religious subjects. Luckily, Magnitsky himself was finally accused of corruption and expelled from all official positions. After 1827, Lobachevskiy was the rector of the university, which soon became a very advanced scientific organisation. In later years, it produced many famous mathematical names, such as the mathematical logicians Vassilyev and Platon Poretskiy, the mathematicians Prof. Lavrentyev (the father), M. Lyapunov[38], Chebotarev, etc. Lobachevsky himself was not recognized for many years as the creator of a new geometry. Only Gauss, in a private letter from 1840[39], praised him for his pioneering work "Geometrical Research with the Theory of Parallels", published in Germany in 1840. On his recommendation, Lobachevskiy was elected to Göttingen University.

The university in Kharkov was also opened in 1804. Its first rector, Professor Osipovskiy, was a brilliant scientist who made significant contributions to its progress. However, he too was finally accused of atheism. His famous student Ostrogradskiy was also accused of the same sins in 1820 (see his biography). However, the university has remained an important scientific institution until our time. The mathematical school of St. Petersburg University (opened in 1819) began with Euler. Its three principal subjects were the theory of numbers, mathematical physics and probability theory. The first two were heavily influenced by Euler himself. The successful development of French mathematics also made positive impact on its progress. Two of its famous professors, V. Bunyakovskiy and M. Ostrogradskiy, studied in Paris and P. Chebyshev worked there as a scientist and was elected to the Paris Academy. Chebyshev developed the theory of numbers and taught it to several outstanding scientists, first of all to A.A. Markov. He and Bunyakovskiy invented famous calculating machines, though he devised his "arithmometer" for mathematical demonstration rather than for routine calculations. Chebyshev's interest and contribution to precision mechanics and its mathematical aspects continued the tradition of Kulibin's practical works (conducted during the 1770-90s). Bunyakovskiy performed important research in the application of probability theory to statistics, and also devised his calculator "Self-Abacus" to assist a census. Several decades later, a similar idea inspired Herman Hollerith to invent his famous "Tabulator". In 1859, Bunyakovskiy discovered the Cauchy-Schwarz inequality, 25 years before its famous rediscovery by Schwarz. It is interesting that Bunyakovskiy did not understand the significance of Lobachevskiy's geometry; in his attempts to prove Euclid's postulates he did not even mention him. A similar, even more negative reaction came from Ostrogradskiy (see his biography), who himself was really an outstanding and progressive scientist. His attitude toward the sensational inventions of Semen Korsakov was also negative. Korsakov was the author of the first punched card machines for information processing and also the author of a book on artificial intelligence (both in 1832, see the article). At the same time, Ostrogradskiy actively supported Chebyshev and his inventions, Slonimskiy, prized Staffel, Kummer and many others (see I.A. Apokin).

The contribution to the field of mathematics by the Moscow University -established largely by efforts of Mikhail Lomonosow[40] in 1755- was minimal until the appointment of Professor Nikolay Brashmann in 1834, by whom mathematics was paid

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36 Bartels also introduced Lobachevskiy to Gauss, with whom he was in friendly correspondence.

37 The last decade of the liberal rule of Alexander I (he died in 1825) was characterised with his rapidly growing mysticism and the subsequent general atmosphere of religious reaction. His younger brother and successor Nikolay I (ruled 1825-1852) oppositely was very realistic person though rather conservative.

38 Astronomer Mikhail Lyapunov, the father of the world famous mathematician Alexander Lyapunov (1857-1918).

39 published in Germany in the end of the 1850s.

appropriate attention. Although Brashmann was a rather traditional scientist, he was an outstanding teacher and organiser. He also taught and influenced P.L. Chebyshev, who greatly respected him and maintained a life-long correspondence with him. On his retirement in 1864, Brashmann established a university prize on mathematics from his personal account and founded a regular mathematical seminar at his private house with colleagues and former students. Soon (on September 15th,1864), the seminar was officially arranged as a regular scientific society for the development of mathematical science and its popularization. Its ideology was formulated by one of its founders Prof. A.Y. Davydov (1869) as "the study of natural laws as the only true goal of science". The general theoretical orientation naturally did not reject applied problems. Nevertheless, due to this ideology, the Moscow school of mathematics became one of the world's most powerful centres for theoretical research. Regular public lectures were conducted and in 1865 the bi-annual journal "*Matematicheskiy Sbornik*" [Mathematical Collections] was established on the basis of the accumulated material. It was the first Russian scientific journal published in the Russian language. The foundation of this journal was the initiative of the famous mathematician Nikolay Bugayev (1837-1904), graduate of the Moscow university and later student of Karl Weierstrass[41], Liouville and Kummer. Bugayev joined the society in 1865 and was its president from 1889 to 1904. He insisted on the extensive popularization of foreign achievements and simultaneously on the development of Russian scientific terminology and publications in the Russian language. However, in 1896, the French list of contents was added. Since 1924, the articles have been printed in all basic European languages. This world-famous journal exists today; in the post-war years, it published many works on cybernetics, programming and computational mathematics. Bugayev's actions had very little in common with any nationalistic arrogance. After the establishment of the Academy and a period when German and Latin were the languages of Russian science (despite the Academy president's -Prof. Korff's- attempts to introduce some Russian in the 1850s), all Russian society had turned to French. This was the reason of Semen Korsakov's publication of his book on artificial intelligence in French in 1832, and of Krylov's French descriptions of his mechanical integrator in 1904. Ivan Sleshinskiy made an excellent translation of Couturat's "Algebra of Logic" soon after its appearance in France in the 1890s. Even Alexey Lyapunov cultivated his French, already in our time, and was a member of the French cultural society for most of his life. However, the intensive democratic reforms of the 1860s turned the Russian educational system into one of the most accessible (on all levels). The following industrial revolution increased the demand for educated specialists from all social categories in an almost explosive way. For young university professors, the natural demand for teaching in the

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40 Mikhail Vassilyevich Lomonosov, "the first Russian academician at the Russian Academy", was the founder of the Moscow University. He was born in the Russian North, near Archangelsk, to the family of a rich fishing enterpriser. He was educated to be clergy, but himself studied L. Magnitskiy's "Arithmetic" and was interested in natural sciences. At the age of 19, he ran away form home and walked (!) with a fish merchant's caravan to Moscow, where he graduated from the religious Slavic-Greek-Latin Academy. For outstanding progress he was sent to Germany with two other fellow-students Dmitriy Vinogradov and Gustav Reiser. Lomonosov spent 3 years in Marburg studying mathematics and philosophy under Christian von Wolff. There he also married Lisa Zilch, his landlord's daughter. As a true pupil of Leibniz, Wolff propagated the logical and mathematical approach to all sciences. That resonated with Lomonosov's own feelings. Later he intencively used logical and mathematical reasoning in science. He also studied chemistry and geology under Henkel in Freiberg. He (and Lisa) returned to St.Petersburg to work at the Academy. Later, they moved to Moscow, where he was entrusted with the organisation of the University (later named after him). Lomonosov is famous for his efforts in the promotion of Russian science and for his outstanding scientificcontributionsto chemistry, mineralogy, physics, and poetry.

41 K. Weierstrass (1815-1897) also taught and influenced other Russian mathematicians - e.g. I. Sleshinskiy, and especially Sofia Kovalevskaya (1850-1891), outstanding scientist and the first woman professor of mathematics. As a woman she was not admitted to Russian and German universities. He taught her privately 6 years -since 1870- and later supported her in obtaining a professorship at the university of Stockholm (1883). Weierstrass greatly admired her scientific and personal qualities and maintained an intimate correspondence until her premature death. In 1889 on the initiative of Chebyshev she was elected for the Russian (Imperial) Academy. (*L. Vorontsova*. Sophya Kovalevskaya (in biographical series). Moscow: *"Molodaya Gvardiya"*, 1959.)

national language was clear. As a scientist, Bugayev began important research on infinite series and contributed to number theory and the theory of functions. As a teacher, he did much for mathematics and greatly influenced his students. One of them Dmitriy Egorov (1869-1931), who learned in 1887-92, also joined the society, and made a significant contribution to differential geometry; later he created his own school, working on the functions of real variables. Egorov himself greatly influenced Nikolay Lusin (1883-1950), his student since 1905. Lusin was the most famous Soviet mathematician to work on set theory. During his spiritual crisis, which Lusin experienced as a very emotional person, he was supported by Egorov, who himself was deeply religious[42] and also by his intimate friend and fellow-student Pavel Florensky[43], who also passed through a similar crisis[44] and turned both to science and religion[45]. In 1910-14 Lusin studied in Göttingen, partly under Landau. Under Egorov's guidance, Lusin submitted his extraordinary (doctoral) thesis on the theory of functions. After the Socialist Revolution of 1917, Lusin and Egorov formed a powerful student research group at the Moscow University[46]. This group included many future Soviet mathematicians who influenced and promoted the establishment of computers and computations. Among them were the Academicians M.A. Lavrentyev, A.M. Kolmogorov, P.S. Alexandrov, L.A. Lyusternik and Prof. Nina K. Bari and Lyudmila V. Keldysh. Also, Pavel Uryson (1898-1924) and Lev Shnirelman (1905-1938) performed significant research on topology and number theory. In the 1930s, Lusin himself taught mathematics to Alexey Lyapunov who is recognized by the world's scientific community as the founder of Soviet cybernetics.

In the 1920s, Otto Schmidt[47] established a new seminar on set theory, which soon expanded its algebraic interests. A noticeable influence was also exerted by Emmy Noether (1882-1935), a professor of Göttingen university who worked in Moscow in 1928-29. Noether was one of the creators of modern abstract algebra. This school also integrated topological research and subsequently turned into another scientific centre. In 1952, the Academician Sergey Sobolev (1908-1989) became the head of the first computational mathematics department in the USSR, which he organised at the Moscow State University. Sobolev invited A. Lyapunov, who immediately started research aimed at programming and its mathematical foundations. In the early 1950s, Lyapunov and his collaborator Yuri Yanov created so-called programming schemata (mathematical modelling of algorithms) as well as the mathematical "operator method of programming". In 1953, Sobolev and Lyapunov established the very popular "Big Programming Seminar" at the university, which in fact was the first cybernetic seminar[48]. Its regular work was very successful; the seminar -which worked ten years- concentrated all progressive scien-

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42 As religious person with very firm principles, Prof. Egorov supported scientists who were oppressed for their "religious ideology" in the late 1920s. He himself was imprisoned in 1929 and died two years later. He was a respected member of the Mathematical Society in Moscow. Most of his fellow members refused to publicly condemn him and later some of them were repressed themselves.

43 Pavel Florenskiy was an Orthodox priest, religious philosopher, engineer and an "encyclopaedic" scientist. He died in a prison in the 1940s. Among others, he wrote on the theory of folk art and composed an interesting mathematical work on geometrical representation of imaginery values. P. Florenskiy. Mnimosti v Geometrii [Imaginaries in Geometry]. Moscow, 1922 (Munchen 1985).

44 Such a state of moral crisis was not a coincidence. The approaching end of the Russian monarchy obviously provoked some social and spiritual instability, especially in younger people. The search for new moral values brought many either to science or to religious philosophy, although some also turned to political activity. Similar movements could be traced in the end of the 16th century and in the 1980-90s.

45 The episode with Florenskiy was characteristic for that time. He "discovered the low cognitive possibilities of the natural sciences" and was impressed by Bugayev's lectures on discontinuity. This subsequently convinced him of the importance of an integral approach. It was then that the "antecedents" of modern cybernetic methods began to appear.

46 After the revolution, the university was renamed as Moscow State University. The students named their group "Lusitania" after Lusin, who was an extraordinary teacher.

47 The Moscow academician of mathematics Otto Yulyevich Schmidt (1891-) graduated in St. Petersburg under one of P. Chebyshev's talented students, the Soviet academician, Dmitriy Grave (1863-1939) famous for his development of the mathematical foundations of applied topography.

tific powers which a little later opened the way to Soviet cybernetics[49]. In 1960, Sobolev established and headed the new (Siberian) academic centre in Novosibirsk. Lyapunov joined him. Soon, this centre became one of the leading institutions for cybernetics and programming. Also, Lev Kantorovich, the creator of economic cybernetics, Andrey Ershov, the famous Soviet programmer and mathematician, and many other cyberneticists came from this centre or worked here for years.

The principal social transformations and turmoil of the 1910-1920s (wars and revolution) not only brought destruction but awoke numerous new creative forces. Not only mathematics but also electrical engineering and electronics developed intensively in the 1920s and 1930s. The state program for the intensification of power production (GOELRO)[50] stimulated the progress of related sciences and education. The Moscow Power Engineering Institute and the All-Union Electrotechnical Institute, simultaneously established by K. Krug[51] on government directive, had a decisive impact on the early period of computer engineering. In reality, it was the "explosion" of power engineering that subsequently lead to the birth of the first digital computers (Lebedev's experiments in the 1930s, his and Bruk's first electrical analog machines, the first computers of the M-series, etc.). Their direct engagement in the solution of military problems can be dated to the early 1950s. Among the interesting computer-related technical inventions, we should mention the *electro-optical reading machine* (1938), the world's first "scanner", invented by the young Moscow engineer V.E. Agapov. It was built with photo-diodes, and could "read" and convert a standard type-written text into series of electrical signals. It had the size and shape of the common piano. This machine was presented at the office equipment exhibition "Automation of the Labour Organisation" (a priority issue then[52] /G. Povarov) in 1938 (described in the catalogue) and exhibition of calculating machines, "Socialist Accounting", 1949 (in the exhibition description, Moscow, 1949-50, p. 8.)[53].

The beginning of 1970s coincided with a certain reduction of international tension and are believed to be the turning point from the completely original development to the beginning adoption of the western standards and architectures. Although the lack of developed standards and insufficient level of "ready made" software for commercial production[54] lead to implementation of the IBM programming standards and some supporting computer architecture elements, it did not stop the Soviets' own scientific and engineering progress. Besides, we know that the constant flow of various novelties is a specific feature of the whole Russian cultural history, nevertheless they were almost never dogmatically accepted but often transformed or performed auxiliary functions in own creative process. The scientific cooperation backed by the progressive ideas and information exchange was always considered a positive process, which in fact could have started much earlier, however, except that individual commercial interests and political separationhamperedit. Nevertheless theEast Europeancommunity used the advantages of its extensive internal co-operation. It was also well protected from the world market's

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48 See the article on the Lyapunov's programming seminar (in the present volume).

49 See the article by D.A. Pospelov and the Lyapunov's biography.(Ibid.)

50 GOELRO =Gosudarstvennaya Electrificatsiya Rossii [State Electrification of Russia].

51 Karl Adol'fovich Krug (1873-1952), USSR academician, Prof. of Electrical engineering, one of the leading scientists in the GOELRO plan. In 1922-25 he established the two largest Soviet electrical institutions in Moscow. S. Lebedev made his first computer inventions in one of them, while T.Alexandridi, M. Kartsev, N. Matyukhin, N. Brusentsov, A. Zalkind, E. Filinov and many other computer inventors graduated from the other one (see in the present volume).

52 The government concern with the" labour scientific organisation" subject was often officially emphasised, e.g. by Molotov (one of the Soviet leaders) in the journal "Bolshevik", 1939, N7, p.14. It also was the official reason of L.V. Kantorovich's work on the Leningrad plywood factory production process mathematical description (modelling) in 1938, which lead to the linear programming and his "economic cybernetics". (See his biography in the present volume).

53 The materials on Agapov's "scanner" are provided by G.N. Povarov.

54 Could it also be a form of some process of the globalisation of science? Luckily, we do not have two (or more) incompatible INTERNETs, one for each half of the globe (or one for each continent) /A.N.

direct commercial pressure. Within a short period the common production of the own compatible machines (ES) was established. They supported the software available on the international market but their design remained essentially original. This fact is not well known in the West, but it had very important consequences. The common education system based primarily on the universities and institutions of the USSR, and also GDR, Czechoslovakia and some others, turned the intensive training of computer specialists into one of its focus points (also see F. Naumann). Because of this, their number as well as their common scientific potential rapidly increased. Both the principal absence of market competition or any form of mutual economic suppression and the policy of mutual support, which was especially efficient in the science and education fields, turned most of the East European countries into stable computer producers. Although their industrial technologies and the quality of serial electronic components were essentially inferior in comparison to the West, the Eastern countries solved most of their scientific, educational and economic problems with the own computers. Their own science and production steadily developed until the crisis of the 1990s. The traditional, close scientific and economic relations between Russia and Germany were quickly restored in the post-war period and the GDR remained the USSR's closest partner, also in computer production. The GDR computer veterans remembered that the achievements of Soviet science were always so impressive that, "we all had a feeling of being well protected and sincerely believed in the almost limitless possibilities of our common science"[55]. The East European experience of common computer development could be obviously valuable both for the future of European and the whole of international science.

Cybernetics and Society (The Archaeology of Computing as a Cultural Science)

The blockages in the development of the Soviet computer were both of a material and ideological nature[56]. While material shortages were sometimes productive and led to original new solutions, political interventions slowed down scientific research and practice. Until the end of the Stalin era, cybernetics remained ideologically discredited; the physical implementation of electronic circuits was both a political problem and a provocation to the socialist notion of working (e.g. Lebedev´s works at the Institute of Energetics)[57]. When Georg Klaus developed his version of cybernetics for the control of socialist economics in East Germany, its' very essence (feedback loops of self-regulation, network thinking and de-hierarchized structures) contradicted the practices the socialist regime[58].

Even before the October revolution, the Russian intelligentsia had modelled a psychophysiological renovation of man through machinic techniques, reaching from the total organisation of working processes up to the invasion of the cosmos (Russian taylorism and Alexander Bogdanow´s organisation science of *tectology*)[59]. In the socialist concept, this mechanisation – different, for an example, from Italian Futurism – was not meant as an idealization or aesthetization of techniques, but referred to a new type of man – which explains the inherent ideological limits of Soviet cybernetics. At least in the early 1930s, the aesthetic ideal of techniques was politicized, with the mastering of techniques being functionally referred to as the "pushing through" of socialism[60]. The

55 See the proceedings of Tagungen GTG SHOT, München, August, 2000.

56 On the "ideology of computing", see the contribution of Y. Khetagurov on special computers (in the present volume).

57 See the contribution of D.A. Pospelov, Establishing Informatics in Russia, (Ibid.).

58 Carl Wege, Buchstabe und Maschine. Beschreibung einer Allianz, Frankfurt/M. (Suhrkamp) 2000, p. 186.

59 Russian physician and philosopher Alexander A. Bogdanov had published an extencive work dealing with the scientific principles of society control. "The Universal Organization Science Tectology", Leningrad-Moscow: Kniga, 1925-1928.

60 Klaus Städtke, Wandel im Technikbewußtsein, in: Wolfgang Emmerich / Carl Wiege (eds.), Der Technikdiskurs in der Hitler-Stalin-Ära, Stuttgart / Weimar 1995, 178f (179).

anthropocentrism in the Soviet technical discourse thus approached Alan Turing's conception of man as a *paper machine*, when Stalin, for example, addressed Soviet literary authors in the following way: "You, the writers, are engineers as well, guiding the construction of the human soul."[61] On an aesthetic level, the electrification of poetry had been hailed in Russia by A. K. Gastev in analogy to psychomechanics. "The author´s role in this technology was to design, even engineer, the arts of the written words."[62] When the present text refers to the *technical-discourse*, this explicitly refers to the discourse theory of Michel Foucault - a theory which is not about semantics; the word *discourse* itself is used by Foucault "in a peculiarly technical sense, signifying not what is being said but what is actually not being said" - rather the quasi-machinic relation between the things than material or verbal objects[63].

The sociologist of science Bettina Heintz recently pointed out the fact that, in spite of a common belief, mathematics is not the incorporation of objectivity and universality but subject to temporally specific cultural patterns of experience and interpretation[64]. In Karl Mannheim´s way, we have to investigate for the Russian case to what extent the specific constitution of the communist regime, with its emphasis of human working power as opposed to robotic machines, has hampered a computational thinking which, taken separately, was impressively advanced. While, in 1936, Alan Turing adressed the notion of mathematical algorithms with a translation into machines, in the same year Emil Post - an American mathematician - chose the metaphor of the assembly line for this process, thus revealing the imbeddedness of formalistic mathematics in the contemporary economy. Like so many other cases, Bettina Heintz´ research leaves the development of machinic thinking in the former Soviet Union unnoticed, where Leonid Vitaljevich Kantorovich developed the concept of linear programming from a similar context of production automation in factories and in 1939 published his book on mathematical methods of planning and organizing industrial production. It was there that he for the first time developed his conception, theory and algorithmics[65] - with "linear optimization" in socialist production processes being a hot topic in the 1960s[66].

The development of the Russian computer was not only determined by military uses, but by infrastructural necessities as well – such as the supply system for electricity[67], playing a decisive role in the state economy (Lenin´s motto "electrical current plus the power of the Soviets lead to communism"). At this cross-road of technology and economy, the energetic and the informatical uses of the electric impulse interfere. Applications in economy and other civil uses urged the development of alphabetical input-output-devices of the computer and generated appropriate interfaces for the real time control of production processes. The art of computer programming asked for means of visual control (as in the case of the computer MIR-2), finally leading to computer-aided-design for the development of computers themselves. This emancipated the machine from man, as expressed by Apokin in his present contribution: The computing system *Auto-operator*, produced in 1962, was the pioneer project in the field of industrial technology automatic control. It was a digital direct-control system without the intermediate transformation of discrete signals into analog signals. A genuinely techno-historical interrogation of the genesis of computing in Russia cannot be performed on a mathema-

61 Quoted after: Hans Günther, Die Verstaatlichung der Literatur, Stuttgart 1984, 11f. See as well Carl Wege, Buchstabe und Maschine. Beschreibung einer Allianz, Frankfurt/M. (Suhrkamp) 2000, esp. 17ff (engineering / writing) and 184ff (cybernetics / society)

62 Cecilia Tichi, Shifting Gears. Technology, Literature, Culture in modernist America, Chapel Hill / London 1987, 16.

63 Paul Veyne, Der Eisberg der Geschichte. Foucault revolutioniert die Historie, Berlin (Merve) 1981, 5.

64 See Bettina Heintz, Die Herrschaft der Regel. Zur Grundlagengeschichte des Computers, Frankfurt/M. and New York (Campus) 1993.

65 See the contribution by D. A. Pospelov and J. I. Fet in this volume, who refers to parallel developments in the West, by that time unknown to Kantorovic (Tjalling Koopmans, George Dantzing et al.).

66 See the contribution by D. A. Pospelov and J. I. Fet in this volume, and Wege 2000, 186.

67 See the contribution by I. A. Apokin, Electronic computers (in this volume), on the example of I. Bruk 1950.

tics-based reconstruction of machinic thinking alone. Did political totalitarianism and the machinic option of "Nothing must be left to chance" (Wassén 1951) go hand in hand? The convergence of cybernetics and state reasoning (the art of control in general) was expressed by André Marie Ampère in France[68] as early as in 1838, in his principal work on the classification of sciences[69], by the Polish philosopher Bronislav Trentowski[70] in1843 and by the cultural historian Ernst Kapp in Germany in 1877.[71] "Mechanical devices have the analytical advantage of being structurally transparent in the sense that the assembly of their parts and the processes they thereby embody are rationally planned and under the conscious control of a designer"[72]; in totalitarian, planning-based societies political problems are usually subsumed under the notions of information and observation. The essence of despotic regimes thus is the techno-archive, with its ideal being the completely storable information (Peter Berz). In the context of the rationalization ideology of modernity, it is interesting to investigate the ways how, for example, the Russian academician E. I. Samurin could subsume both the hardware of calculating machines and libraries under the key-word "classification"[73]; the prototype of most information retrieval devices, serving as a model for most computer applications in the field, is found in almost all traditional libraries. As early as 1832 – at a time when mechanics still was part of applied mathematics - Semen Nikolajevich Korsakov from the statistical department of the Russian ministry of police announced, apparently independent from Charles Babbage in England, his machine "for the comparison of ideas", a punched card-based apparatus for the automated comparison of data[74]. At this exemplary point, an evaluation of the specificity of the Russian contexts is called for - both as an epistemological dispositive and as a concrete series of events. The switching from civil to military production in 1914 and the following abrupt emigration of the Odhner calculating machine production from Russia to Sweden caused by the October revolution marks such an incisive intervention of historical events in the development of apparatuses[75]. One world war later, S. A. Lebedev in Moscow was already approaching the construction of a computer on the basis of binary arithmetics when he was interrupted by the Russian involvement in World War II in 1941[76]. Coming back to the key-word of cybernetics, we are reminded that it was developed as a technique of regulation in the Bell Telephone Laboratories in the USAas an effort to optimize the direction of ballistic fire during World War II (naming Claude Shannon, Nyquist, Norbert Wiener). While this term in the Western hemisphere, after a fashionable popularization, lost its impact with time (until its disguised renaissance in the notion of *cyberspace*), in the Eastern block it was heavily being associated with the option of modelling society. However, this led to a de-coupling of computing science (informatics) and the practical craft of engineering. It was only in the late 1950s that "the engineering of logic was joining the artificial intelligence"[77]. Among the more concrete lines of the present research is the effort to clarify the degree to which - compared with the German and American practice - ballistic missile techniques on the one hand and cryptology on the other hand were coupled with the development of computing during the second world war and the time immediately after.

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68 A little known fact described by G.N. Povarov in his book "Ampère and Cybernetics", Moscow, Radio, 1976.

69 "Essai sur la Philosophie des Sciences, ou Exposition Analitique d'une Classification Naturalle de Toutes les Connaissances Humanies". Paris, Bachelier, 1838.

70 "The Relation of Philosophy to Cybernetics, or the Art how to Govern Nation". Poznan, 1843.

71 Ernst Kapp, Grundlinien einer Philosophie der Technik. Zur Entstehungsgeschichte der Cultur aus neuen Gesichtspunkten, Braunschweig (Westermann) 1877, 342.

72 Klaus Krippendorff, Principles of information storage and retrieval in society, in: General Systems Bd. XX (1975), 15-34 (17)

73 E. I. Samurin, Geschichte der bibliothekarisch-bibliographischen Klassifikation, Leipzig (VEB Bibliographisches Institut) 1964 and Munich-Pullach (Verlag Dokumentation) 1968.

74 See the contributions by Gellius N. Povarov in this volume.

75 See Henry Wassén, The Odhner History. An Illustrated Chronicle of "AMachine to Count on", Gothenburg 1951, 43.

76 See I.A. Apokin, Electronic computers (in the present volume).

The history of the first computing projects does not prove the popular opinion about the (consistently) stimulating role of war in their appearances. Though ENIAC was really financed from the USA military budget (as was the COLOSSUS from the British budget), one should not forget that it was the beginning of the war that interrupted Atanasov´s nearly completed project. The same thing happened with the work of S. Lebedev and the project of K. Zuse (until 1943) which was supported only by his personal enthusiasm. In this sense, we can speak not about acceleration but rather about three years delay (approximately) especially in the European countries directly affected by war[78]. Did the transformation from mainly military to more civil uses of computer technology after the Second World War happen in the Soviet Union in forms comparable to structures in the West? A media archaeology of computing in Russia here offers peculiarities which reach far beyond purely antiquarian interest, but make sense even under the aspect of recovering alternatives to current computer architectures, such as on the field of *parallel computing*, as well as with the experiments on the ternary rather than binary computer SETUN performed by Nikolay P. Brusentsov: "The basic feature of ternary logic is its better correspondence to our human logic"[79], referring in a somewhat different way to the logical studies of Aristotle who had introduced the notion of the void as an abstract variable into the calculating process.

The period covered by the present research project extends until the 1970s, that is until the moment of the (internally) controversive adaption of the Western IBM-360 standards in the computing industry of the USSR; single contributions in the present volume though follow the development until the 1990s, that is until the political collapse of the Soviet system, when questions do not stop to insist – such as the experiments with artificial intelligence and neuronal net works[80].

Until the time of its political deconstruction the USSR had – except for systems of aerial defence - not developed a functioning global computer network (even if this had been thought of)[81]; instead, the emphasis had been put on making the diverse computer architectures compatible. With the advanced URALseries "for the first time a compatible computer system had been created to a large degree which by means of a special coupling unit permitted the establishment of a multi-computing system as well"[82]; in 1969, the standardized system achieved by agreement between the Eastern Block countries for electronic computing ES (German: ESER) provided the according infrastructure.

Under the perspective of the present study, it was partially the coupling of the USSR to the standards of computing defined by IBM which marked the beginning of the internationalization of Soviet computing or at least "a decisive moment of Soviet computer history" (Nitussov/Malinovskiy). This datable event marks a computer-archaeological breaking point, a discontinuity for which the death (the broken heart) of Sergej Lebedev – the unspoken hero of the first generation of Russian computing – has been almost allegorical. Can a hidden historical continuity still be maintained?

Until now, many experts keep insisting that the wrong decision interrupted the original line of Soviet computing; it lead to the increased copying of American machines and finally brought about the total crisis of the 1990s. Others oppositely insist that the implementation of foreign standards was in fact very relative and did not in any way interrupt the original development, but just "moved" it slightly into another direction[83].

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77 G. N. Povarov, Logic, automation and computing (in the present volume).

78 Apokin, Electronic computers ("Some Conclusions"), in the present volume. Also see as well the contribution by Yaroslav A. Khetagurov, Some notices on the development of special computers in Russia: "The beginning of the war did not expedite but hampered this work in the USSR, unlike research in other countries."

79 N. P. Brusentsov, as quoted in the article by B. N. Malinovskiy and the same author in the present volume.

80 See the article by A. Kassatkin and L. Kassatkina.

81 See the contribution by S. Burtsev and Malinovskiy´s biography of Viktor Mikhailovich Glushkov in the present volume.

82 Naumann, in the present volume.

83 Alexander Nitussov / B. N. Malinovskiy, The global social and economic changes of the sixties (in the present volume).