THE JOINT PROJECT ARIFMOMETR
AN ARCHAEOLOGY OF COMPUTING IN THE USSR

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1. Introduction: Plea for a European history of computing

The research project Arifmometr is among the first systematic scientific studies on the general history of development of both Russian computer engineering and Russian computer theory ever performed in an European context. The basic idea and main objective of the project is the creation of a systematized, complete and adequate scientific review of the development of Russian (USSR) computing for the European audience. Subject of the study will be Russian computing with its specific features in the context of European computer development and scientific and cultural progress from the first counting devices and theoretical works of the beginning period until the end of an independent development in the early 70s (when computer science and industry in the USSR adopted and became compatible with American IBM standards). The aim is to fill the gap in knowledge on the subject and to represent a more complete general picture of European computer science and computer culture.

All essential aspects of the subject such as

- the early arithmetic devices and computers themselves (including the first electronic scanner and the use of computer images),
- theoretical works on automata and algorithms (Kolmogorov; Markov the older and the younger; symbol manipulation instead of calculating functions),
- the most important tasks and applications (plans of computer networks encompassing the whole Soviet Union, as conceived by Mjasnikow),
- programming and applied programs (Kantorovic: linear programming),
- the works on artificial intelligence and cybernetics,
- unusual decisions based on the political, social and economical situation,
- the biographies of the most famous Russian computer pioneers, inventors and scientists will be treated.

All aspects and results of our study will be illustrated and verified by numerous facts and examples of original inventions and discoveries made in Russia (USSR). The outcome of our studies will be presented according to the historical chronology, the archaeology of respective media (hardware), the logic of development and the increasing demands given by the progress of society. The study should provide better possibilities for the evaluation of the original nature, the real role and the potential of Russian computer science, both historically and virtually. Needless to say that such a task can be performed only by joint efforts of several specialists and organisations.

The project Arifmometr was started in 1996 on the initiative of the Department of Art and Media Sciences at the Kunsthochschule für Medien (KHM) in Cologne. This Academy of Media Arts has been the first academy in the Federal Republic of Germany that is devoted to all areas of audio-visual media; it began its teaching programs in October 1990, offering a basic eight semester

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undergraduate program and in addition a four semester postgraduate education. The name "Academy of Media Arts» itself expresses the entire spectrum of its interests supported by teaching and research at this institution, namely art in the age of its technological (re)production.

Regarding the course of events, it is by no means a coincidence but quite logical that a young European organisation of such profile and orientation, which does not stagnate in its own isolated aims but is actively working to enrich the quality of the general media landscape, pays attention to the archaeology of computing - one of the most important modern media tools.

The picture of European computing development would be incomplete if it did not include the real achievements of all European countries no matter to which political block they once belonged or still belong. Nevertheless the progress of Russian (Soviet) and East European computer science and industry is still a terra incognita for their Western neighbours. Even more, in spite of its own successful pioneer projects, well developed computer science, industry and numerous sophisticated applications, until now many Europeans believe that the computer is an entirely American creation and that the Old World is more or less just a 'consumer' of both its advantages and 'ready made products'. The fact that we now see only a few suppliers of microprocessors on the world-wide market lets us often forget that once there existed an active and vivid culture of hardware development in Europe. For a short period Russia was even ahead of the American technology and came up with very elaborated ideas and many independent approaches. Therefore one aim of the Arifmometr project is to remind that - in contrast to the current situation - in the beginning of the electronic computer development different interesting architectures built a coloured bunch of competing approaches.

Conducting historical research of computer development and forming its global European picture is necessary not only for scientific interests but first of all for making existing information on the subject accessible for all who are concerned and interested. Such an historical research digs up facts and data unknown for a wide circle of specialists and brings to light advanced projects and ideas which have not lost their practical relevance until now. With the analysis of its results criteria for the rational choice of perspectives and directions of further European developments can be formed; even a fragmentary observation of the subject shows that the joint potential of our continent is far from being properly realised. The picture of European computing and its history, though, is far from being completed; a lot remains yet to be studied.

2. The current state of research and its archival and methodological basis

The European audience has practically no information about anything that has been done in Russia on that field. Few foreign publications of Russian authors which appeared in different countries were dedicated to special scientific subjects. Most of them were of mathematical nature or theory of programming and had only implicitly to do with the historical context. These works could not even create an approximate impression of the real state of the art of computing in Russia. One of the rare exceptions is a report prepared by two Russian mathematicians, M. R. Shura-Bura and A. P. Ershov, for a conference in Los Alamos, USA (1976)[2], as an attempt to describe some first fifteen years of the formation and development of computer programming in the USSR. Several other reports of Soviet scientists appeared in different years only in conference proceedings and are now practically forgotten. The participation of Sergej Lebedev with a group of his collaborators at a conference in Darmstadt, Germany (1956), where he told about his first machines, might be one of such examples.

[2] Andrei P. Ershov / Mikhail R. Shura-Bura, 'The Early Development of Programming in the USSR', lecture carried out at the International Research Conference on the History of Computing, Los Alamos. New Mexico 10-15 June 1976, published in: M. Metropolis et al. (eds.), A History of Computing in the Twentieth Century, New York 1980, 137-195

The problem of insufficient information cannot be solved by a mere translation of some Russian historical books or archival documents. Apart from a few exceptions, historical books do not exist in Russia or the Ukraine, where the subject is just beginning to be studied systematically. Archival documents are not always accessible for several reasons, the most essential of which is a certain atmosphere of strict secrecy once imposed on all computer research and manufacturing works by official regulations since the very beginning. Similar to the conditions in the USA, the creation of computers in the USSR was initiated by a government policy of performing tasks for nuclear physics, rocket (later space) purposes and the further development of the defence industry. For decades the related documents were kept in secret archives or in private libraries of the inventors. In Russia, the past is unpredictable (Povarov); thus any research into the genesis of computing in Russia requires an "archaeology" of its own kind.

The arguments mentioned above should not be understood as if nothing was known in the USSR. The first books about computers appeared in the beginning of the fifties, since the new branch needed to acquire specialists for creating new computers and operating the existing ones. The universities established new laboratories, programs and curricula, and the scientists needed new information. Books on computer subjects were published by thousands. At the beginning period there were no specific military computers; thus the subject of secrecy were not the machines themselves or programming, but the 'special' (military) applications and technology. The relative absence of civil applications for computing in the formative years and its almost complete detachment from military developments is a characteristic of the situation in the USSR. The strict separation between military and civil applications might be best illustrated by the fact that the military community had their own scientific magazines, published in a very small number of copies and not available for the general public.

In the beginning period and with only fragmentary information available, the history of computing in the USSR could not be subject to serious research. Later, at the end of the sixties, a few Russian historians who were also computer specialists started their work by studying the early period of mechanical calculation (mechanical devices and logic machines) and the period of parallel (USSR and foreign) development of electronic computers. There are a few articles and reports on these subjects. They describe only particular topics connected with the progress of civil computing and the interesting and really original Soviet part of engineering, while 'special' computers became accessible (but still not describable) only in recent years. Just two Russian books[3] on computing history were published in 1974 and 1995 in a small number of copies and only in Russian language. In spite of the numerous Russian printed works on hard- and software development as well as on different historical aspects, the scientific history of computing in Russia itself still looks rather fragmentary. While even Russian historians did not have access to all material on Russian computing development, their Western colleagues were of course in a much worse position. The atmosphere of secrecy in the militarised post war Soviet computer industry were responsible for further difficulties of information exchange with foreign specialists. Now, after the Iron Curtain has vanished, there is a significant growth of interest to this subject in Europe and beyond. Even the first East-West conferences on the subject are being held in different places and the accompanying proceedings already try to compare the different developments in Eastern and Western Europe.[4]

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[3] I. A. Apokin / M. Maistrov, Development of electronic computers, Moscow 1978;
B.N. Malinovsky, The history of computers in biographies, Kiev 1995

[4] «Computer und Kybernetik - Geschichte und Perspektiven», Russian-german Symposium held in November 1997 in Heidelberg. „High-Tech History Workshop - East and West« held in January 1992 in Salzburg.
«New Information technologies in historical research and teaching» held 1992 in Ushgorod, Ukraine.
The proceedings of the last 2 conferences are together published in «History and Computing in Eastern Europe», (ed) L. Borodkin and W. Levermann, Scripta Mercature Verlag, St. Katharinen 1993

The Arifmometr research project is being conducted in three countries in parallel: Germany, Russia and the Ukraine. The name 'Arifmometr' was given by German scientists after the famous calculating device - probably the only really well known early Russian "computer". The research project is being performed on the basis of research and analysis of Russian scientific and archival documents as well as on materials and information obtained by personal contacts (oral history method) and joint work with Russian scientists, inventors, historians and participants of the most famous computer projects. Scientific material is being collected, analysed and prepared for further work and publication by scientific consultants in Russia and the Ukraine on the basis of their own experience as scientists, inventors, designers and organisers, based on their private and official archives (the enterprises), on various documents, interviews with their colleagues etc. Material has also been collected by the German team during their trips to Moscow and Kiev, at libraries, museums, archives and personal meetings. The collected materials are being revised and discussed by all experts with the aim of representing it systematically.

The main methodological task of the research is a systematization of the development and its historical description. It is very important not just to demonstrate the concrete facts but also to show the logical line and consequence of their appearance. The development of theoretical sciences with its practical realisation in concrete inventions and devices will be related to the growth of the practical problems which had to be solved. The increasing dimension of such difficulties made the most important and stimulating impact on the course of progress in Russian computing. Several connections with the social conditions will be helpful for a better understanding of some phenomena especially in the Soviet period of computer history.

A comparison with the most progressive and interesting foreign inventions of the same period should help the European specialists in their evaluation of the technical and scientific level of Russian theoretical achievements and concrete machines. This comparison is not just a supplementary historiographical employment but originally inscribed into the course of events: Russian engineers have always already been developing their products in the knowledge of Western parallels - an interlacing which remains to be precised by the research project.

The main principle of the research is its authenticity in the sense of correspondence with concrete archival material and historical, scientifically established facts. The archaeology of computing is carried out with respect to the context of contemporary social, scientific, technological and cultural conditions. It works out the interface between machines and discourse, and is always completed with a comparative analysis of similarity or difference with foreign engineering and scientific achievements, such as the electronic industry in the former German Democratic Republic in its changing relations with developments in the USSR and in the Western hemisphere.

It is very important to follow the development of the Russian computing ideas and realisations both structurally and biographically in their passage from author to author, from engineer to engineer, from generation to generation (e. g. the evolution of cybernetics in Russia: from I. Schmalghausen to A. Lyapunov to Pospelov and the `Operator Method´, from A. Lyapunov to Y. Yanov and then to A. Ershov etc.). A special emphasis of attention focuses on the early off-spring of Russian cybernetics and subsequent computer programming from the bio-mechanical `labour science´ of Gastev in the twenties.

The archaeology of computing in Russia is being structured by inquiring the relationship between hardware (engineering) and software (mathematics) in the course of the development, their mutual tensions, gaps, incompatibilities and disconnectedness - probably one of the main reasons to the failure of a coherent Russian computing industry in the end.

3. First results

The primary analysis of collected material about both, the numerous really existent computing machines, devices and their creators, as well as theoretical works proves the fact of existence of a really original specific 'Russian' computing line. Being a part of the Old World, Russia was generally in the course of foreign (European) scientific news and technical achievements (what could not be said vice versa), but the specific Russian feature was that the inventors always tended to make their creation in their original way and even when having the possibility to directly copy a prototype they preferred to at least improve something (Odner's Arifmometr, calculator of E. Yakobson etc.). Sometimes it was caused by incompleteness of the information, the general character or delays in its delivery and sometimes the search for new ways was forced by a shortage (or lack) of resources or insufficient technologies. All that is valid not only in application to nineteenth century but up to our days. It was the insufficient state of technologies and unsatisfactory level of components that in the post-war time became some of the basic reasons of a really unusual and progressive 'Russian' approach to the solution of computing design problems, such as e.g. Dr. Y. Khetagurov's special processor circuitry for selected tasks, 'art of reliable system creation'[5], etc**.** Often the inventions and discoveries were made really independently though chronologically in parallel with the work of European specialists. Sergey Lebedev who created the MESM machine, realising the principles later named 'von Neuman's' always emphasized that all the information available in the USSR about Western hardware was provided only on commercial advertising level what could not give the slightest idea of its design. The same might be said about all the Soviet computers of the beginning period.

Speaking about Russian history of calculations, most important is the fact that it is not a series of occasional or random inventions but clearly visible lines of original theoretical and practical development. Very specific logic machines of A. Shchukarev and N. Khrushchev (begin. XX c.) appeared as technical realisation of interest to logical science which developed intensively until V. Schestakow suggested the idea of the electric relay as the ideal tool for technical realisation of binary logic (1934-35). Later the theory of logic was developed and realised in electronic computers on programming level. Long time before A. Shchukarev, in the first decades of the XIX c. a young Russian inventor[6] built a machine for 'comparison of the philosophic ideas' which worked with punched cards and utilised same principles as Hollerit's machine much later. He also described the theory which contained many definitions and statements coinciding with modern cybernetics (G.Povarov). Mechanical counting devices of the XIX c. (Slonimsky, Kummer etc.) were developed also in the XX c. until they were replaced by electronic computers. A mechanical integrator invented by navy engineer A. Krylov in St. Petersburg in 1904 was one of the first analog machines. The first electronic trigger - 'flip-flop' invented by radio engineer Mikhail Bonch-Bruevich (1918) became later one of the principle components of every computer. It was also used in one of the first electrical devices for optical reading/input of printed text which was built in Moscow by the engineer Agapov in 1939 and could be seen as a prototype of nowadays scanners. Theoretical works also have a rich history: The operator method of Markov, Lyapunov and Yanov whose operator method was later integrated in works of A. Ershov. The first idea of a connection between evolutionary processes and cybernetic, suggested by Ivan Schmalghausen and developed by A. Lyapunov, as well as linear programming, described first by Kantorovich in 1938 which was later further developed and followed by numerous mathematical works.

After a first inspection of the materials we suggest some generalising conclusions for discussion:

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[5] Prof. Dr. Yaroslav A. Khetagurov „The Art of Reliable System Creation «, in: Academy of Media Arts Cologne (ed.), Lab. Jahrbuch für Künste und Apparate, Cologne 1997

[6] Detailed description by Prof. Gellius N.Povarov (this material is his scientific property).

- There are some specific features in Russian computer development which should be explained to foreign readers, such as the development in the period of the centralised government planning.
- In spite of the availability of certain (often insufficient) foreign scientific information, Russian (USSR) computer science and engineering developed in an almost independent way, especially in the beginning post war period (approximately 1947-70).
- The average level of engineering ideas, design and experimental computer models, as well as the art of programming, were never inferior to foreign analogues (particulary American) and some (realised) projects were even more advanced, e. g. the BESM-6 or the compatible URAL series.
- Specific historical and political conditions brought into being such specific areas of computer engineering (industry) as 'special purpose machines'; at the same time, ideological turns (like Stalin´s verdict on cybernetics as `capitalist´ spirit blocked the development of theoretical informatics. Furthermore, the special meaning of `informatics´ in the USSR (signifying both computer engineering and a methodology of classification and information systems such as in bibliographies and libraries; see f. e. E. I. Samurin) will be taken into account, being somewhat different from the technical terms developed by Claude E. Shannon and Norbert Wiener in Western signal theory.
- The existing economical and corresponding industrial system on the one hand (centrally planned economy) combined with a rather insufficient manufacturing technology on the other sometimes resulted in exceptionally advanced projects, e.g. in the engineering decision (and even ideology) of increased emphasis in system reliability ('special' computers); this emphasis sometimes hampered the development of really promising projects like e.g. SETUN, an exceptional machine with a triplicate logic and codes.
- On the one hand the social, political and economical situation in Russia was very different to the American which resulted in different engineering solutions for similar problems. On the other hand there are also some important theoretical and technical results which were identical but apparently independent developments in the USA and Russia. Examples are the invention of the electronic flip-flop by Bonch-Bruevich (Russia, 1916) and Eccles/Jordan (USA, 1919), the mathematical concept of Information (Schestakow 1938 and Shannon 1948), or the so called ‘von Neuman architecture’. The first electronic computer in the Soviet Union - MESM - used principles which were later called ‘von Neumann’. Although the development of MESM started later than the first English or American computers with stored programs, but it was performed independently. The realisation of identical results in independent projects could be a hint that the resulting structure was close to the achievable optimum with regard to given structure. For a clear evidence the subject needs further attention.
- In spite of giving up most of the original standards and engineering principles which were replaced by copying American versions there are still many actual projects which could be implemented and further developed.

The government decision for the implementation of IBM standards needs special analysis performed by concerned specialists who participated in making this decision. In the following section we will discuss some points about this very important decision.

4. An example for internationalisation of Russian computing: 'The adoption of the IBM 360 standard'

A first logical step in planning the project ‘Arifmometr’ was defining the borders of the time interval which is to be analysed on the first stage of the research. While the lower border (the

beginning) was established almost automatically with the first existing written description of early Russian calculating devices, setting the higher one almost turned into special research. Because the demonstration of genesis and progress of original Russian computing is the main idea of the project, the beginning of the internationalisation of the computer industry seems to be the most suitable moment for that purpose. It was marked by a well known decision of the Soviet government: the implementation of the American IBM 360 standards into the design of universal computers. In spite of being so (sadly) famous, the decision which changed the life of one of the largest computer industries of the world still lacks a detailed analysis and systematic description of the reasons why it was taken. Not less important is the following question for the European computer world: „Was it a manifestation of the insufficiency (weakness) of science and engineering of the potential Soviet partner, or just a demonstration of its social system or/and economical inferiority, related neither to its scientific nor creative power?«

The first results of work with literature and documents on the subject and interviews with our consultants who were also involved in discussions about preparing the decision (M.R.Shura-Bura, Y.A. Khetagurov, a.o.), bring us to some primary conclusions, approved by historians (I.A. Apokin). Having no intention to discuss the decision itself, here we make an attempt to analyse the reasons which caused the necessity of making urgent decisions. At that time three principle factors dominated in the political and economical 'environment' of the computer world. First there was (still) a separation of the world into two political systems with the resulting 'Cold War', which inspired the (computer) arms race and in particular the idea of 'not to be behind (each other)' or 'not to loose time' (in computer-economical development). The other factor was the beginning of some liberalisation in Soviet politics and economy which led to the improvement of international relations and the industrial internationalisation. The third reason was the intensively growing demand for a broad implementation of computers and new technologies into all the branches of Soviet economical life ('not to be behind').

The characteristic feature of the centrally planned and controlled Soviet economy was a market without individual initiative or free finance. The government distributed financial and other resources according to the development programmes/priorities. The government in general supported scientific research and design, industrial manufacturing, including construction of new plants, and education. By governmental decision the 'special' (defence) branch of computer industry was established. The enterprises of all levels, in other words the market, received subsidies only from the government and only for fixed purposes. They had no freedom to buy anything without official (ministerial) permissions or without being included in the plan of development. There was no free sale of computers but only planned distribution. The enterprises did not have direct financial connections with scientific organisations. Another reason of low activity of the market was that the quality of the work was not always connected with the salaries. Very significant was the 'human factor' of government administrators. Important decisions often depended on their level of competence and personal preferences. Such a state of the „market« could not stimulate the progress of hardware and especially software development for purposes of civil economy, in other words for 'mass consumer' needs.

The advantage of a centralized control system was the possibility of concentrating the necessary efforts and financial resources on important subjects. This was the reason for the advanced progress in priority fields of computer development. In spite of the shortage of modern technologies and the destructive economical consequences of World War II some soviet computers (e.g. BESM 6) reached the level of American analogues. But as soon as the subject looses its governmental priority status it normally needs to be supported by an active market of mass consumers (with their various interests) which maintains the further commercial development with numerous practical applications and emphasis on consumer needs, as in the USA. In the USSR such a market did not exist. The economical life is very complex and can hardly be sufficiently guided by

state directives only, even in a small country. In fact the centralized planning system turned out to be unable to correctly estimate and effectively satisfy the needs of the 'soviet market'. Such a situation caused a dangerous disproportion between the high level of scientific and engineering development of computers in the military area, space research, nuclear physics and some other sciences on one side and a slow progress in ‘common economical life’ on the other.

Inadequate competence of some administrators, personal preferences, ‘corporation interests’, and a complicated administrative system created the situation in which alongside with high level computers numerous old fashioned machines of numerous incompatible modifications were still produced. The presence of such diverse (in age and design) machinery itself can be a proof of the inferior situation in programming because in such situation mass production of standard programs was impossible. Another reason could be called an ‘asymmetry between programming and engineering’. The pioneers of Soviet computing were electrical engineers (Lebedev, Bruk, Rameyev etc.) and no matter how clearly they realised the importance of programming their own efforts were concentrated on hardware. The scientific programming schools were formed on a solid basis of theoretical mathematics and as scientific organisations they were mainly interested in fundamental researches. The programming institutes conducted successful research on an academic level and also created special software (programming languages, automatic programming systems) and programs for priority customers. The percentage of ‘common’ programs was insufficient and could not be quickly enlarged because and new tasks needed to be established new programming organisations. They all were subject to the slow working government planning system. The intensive development of economical life in the early seventies clearly demonstrated the fact that civil industry urgently needed intensive flow of mass programming.

The big series of compatible machines were able to support the standard programs that were being developed in the USSR by that time (Rameyev's URAL family). The question became, wether to create everything by themselves with the danger of ‘being behind’ or to implement/copy existing foreign software. It was clear that an international co-operation was more promising. The possible choice was between the American IBM 360 standard which produced well-developed software, that was needed to make Soviet computers compatible with IBM standards, and the British and West German companies ICL and SIEMENS which proposed direct co-operation in joint manufacturing of new machines.

The structure of the system of centralised administrative control left the right of the final decision to a limited group of officials (including scientific/academic administration). Other people independently of their experience or other merits could actually just play the role of consultants. It was a quite typical situation that an experienced scientist who was respected by the officials (e.g. M.Shura-Bura, Y.Khetagurov a.o.) and responsible for some important project arrived with suggestions or explanations to a ministerial appointment only to hear a phrase like: „The final decision is already made.« (By some top authorities, often not very competent). The President of the USSR Academy of Sciences, M. Keldysh, and minister Kalmykov expressed the opinion that it would be better to produce big machines on original Russian basis. At the same time the modern American software was really seductive. The appointed director of the international ES project, Krutovskih, insisted on copying IBM-360 only. That was enough for the implementation of IBM standards, which led to the abandonment of the original line of development.

The procedure of making the final decision in favour of IBM, ignoring the fact that IBM could not have contacts with the USSR for the reasons of the 'cold war' policy. This will be a subject of special description. (by Igor Apokin.)

5. The project schedule

The first stage of the project will be completed when the results are translated into English language and prepared for publication both in Germany and in parallel in Moscow and Kiev. During this first stage also the documents, photographs, original technical papers, etc. for a documentary part of the book will be prepared. This way some original material will be available to Western scientists for the first time.

The following stage could be publishing the computer-archaeological material "in its own medium ", that is in Multimedia and its non-linear ways of display and access. The material about the history, and how it compares with computer developments in the west, would so be made available as both printed material, and on video, CD-ROM or via Internet. Part of the work is the establishment of a 'virtual museum of Russian computing' (in its European context), currently under construction on the Internet home-page of the Academy of Media Arts, Cologne: **http://www.khm.de/**

Publications in the context of the Arifmometr research project:

1. Alexander Nitussov, 'Problems in the search for archival materials on the history of computing in Russia'. A report at the international conference 'Data Conflicts - electronic archives' in Potsdam, December 1996.
2. Y. Khetagurov, 'The Art of Reliable System Creation', in: Academy of Media Arts Cologne (ed.), Lab. Jahrbuch 1996/97 für Künste und Apparate, Cologne 1997.
3. Alexander Nitussov, 'Germany From the First Hands', description of the project in a special program of the German radio channel Deutsche Welle, broadcast for Eastern Europe, April 1998.
4. Georg Trogemann, Alexander Nitussov and Wolfgang Ernst, `Arifmometr - Eine Archäologie des russischen Computerdenkens´, in: Informatik Forum vol. 11, no. 2 / 1997, 102-104.

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Acad. Dr. V.N. Burtsev, Dr. E.N. Filinov and some others (computer scientists, engineers); Prof. D.A. Pospelov, Prof. M.R. Shura-Bura (mathematicians).

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