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Special Issue: *Science in the Cold War*

ABSTRACT Soviet science in the post-WWII period was torn between two contradictory directives: to 'overtake and surpass' Western science, especially in defence-related fields; and to 'criticize and destroy' Western scholarship for its alleged ideological flaws. In response to this dilemma, Soviet scientists developed two opposite discursive strategies. While some scholars 'ideologized' science, translating scientific theories into a value-laden political language, others tried to 'de-ideologize' it by drawing a sharp line between ideology and the supposedly value-neutral, 'objective' content of science. This paper examines how early Soviet computing was shaped by the interplay of military and ideological forces, and affected by the attempts to 'de-ideologize' computers. The paper also suggests some important similarities in the impact of the Cold War on science and technology in the Soviet Union and the United States.

Keywords computers, ideology, military technology, Russia, Soviet Union

'Mathematical Machines' of the Cold War:

Soviet Computing, American Cybernetics and Ideological Disputes in the Early 1950s

Slava Gerovitch

In March 1954, researchers of the Mathematical Institute of the Soviet Academy of Sciences in Moscow were preparing a comprehensive book-length survey of the entire mathematical discipline, *Mathematics, Its Content, Methods, and Meaning*. An Institute-wide 'philosophy seminar', whose mission was to instil the right ideological principles into the researchers' minds, held a special session devoted to the discussion of a draft introduction to the book. One of the discussants displayed heightened ideological vigilance, and proposed that the introduction should de-emphasize the contributions of American mathematicians. 'There is no progressive science or progressive music in America now', he argued: 'They have lured in a number of scientists from all over the world, and now barely manage to maintain their military potential. We will not promote American mathematics'.[1] Another seminar participant voiced a different opinion. 'There are some progressive-minded people [in America], and one should not lump them together with the Wall Street', he said: 'A great majority of American mathematicians have come out of the ordinary folk and do not represent the American monopolistic bourgeoisie'.[2] The question of how to treat science produced by a Cold-War enemy – as a value-neutral body of

Social Studies of Science **31/2**(**April 2001**) 253–287

[0306-3127(200104)31:2;253–287;019098]

knowledge or as an ideological Trojan horse – acquired central importance in Soviet public discourse on American science in the early years of the Cold War.

Historians of Soviet science and technology have long struggled to find proper categories of analysis for the post-WWII period. On the one hand, this period was marred by vicious public attacks on Soviet intellectuals in a series of vociferous ideological campaigns against 'idealism', 'formalism', 'cosmopolitanism' and 'kowtowing before the West'. Those campaigns destroyed personal careers and closed whole areas of research; in a number of disciplines, the most dogmatic trends prevailed, imposing narrow conceptual frameworks and stifling creative thought. This prompted Alexander Vucinich to describe it as a period of the 'triumph of ideology' over science, and to portray Soviet science as a victim of 'totalitarian' control by the Stalinist Party/state apparatus.[3] On the other hand, this was also an era of genuine triumph for Soviet science and technology. As Paul Josephson has observed, in the post-war period large-scale industrial and construction projects aimed at fulfilling Stalin's ambitious plan of the 'great transformation of nature' mushroomed, and the country celebrated an unprecedented 'cult' of science and technology.[4] It was during this period that Soviet scientists built the first Soviet atomic and hydrogen bombs. David Holloway argues that closed defence laboratories served as 'islands of intellectual autonomy', where political controls were relaxed, and scientists could freely exchange ideas.[5] Loren Graham agrees that science sometimes provided a refuge from the harsh reality of Stalinism, but he puts the emphasis on the tremendous amount of funding and government support for science and technology under Stalin, concluding provocatively that money appeared to be more important than freedom for the successes of Soviet science.[6]

While some historians take for granted a fundamental conflict between the Soviet scientific community and the Party/state bureaucracy, others stress various forms of ideological accommodation, pragmatic cooperation, and even institutional integration of the two groups. Mark Adams interprets Soviet ideology not as an essential set of Marxist beliefs, but as a flexible language of negotiation between the Party, the government, and the scientists.[7] Nikolai Krementsov argues that the 'control apparatus and the scientific community became fused not only in their overlapping organizational structures and networks, but also . . . in a common and quite peculiar set of shared images, rituals, and rhetoric', which resulted in their 'cultural unification'.[8] Alexei Kojevnikov emphasizes the gradual diffusion of cultural norms from Party life into science, as Soviet scientists adapted to the regime. They began to play 'games of intraparty democracy', reproducing public rituals of 'criticism and self-criticism', and framing political denunciations as 'creative discussions' of scholarly matters. In this situation, politics affects science via the subtle mechanism of discursive domination, rather than through direct administrative pressure.[9]

Differences in interpretation also arise when historians take one of the two most studied disciplines – physics or biology – as the paradigmatic case

for the rest of Soviet science and technology. The notorious 1948 triumph of the ignoramus Trofim Lysenko in Soviet biology usually serves as an epitome of the 'ideologization' of Soviet science. On the other hand, the case of Soviet physics, which in 1949 produced the first Soviet atomic bomb and avoided a Lysenko-style ideological pogrom, is often interpreted as an indication that the Soviet leadership held a rather pragmatic attitude, and attached the highest priority to 'overtaking and surpassing', rather than criticizing, Western science. Krementsov explains the different fates of biology and physics by their relative value with respect to the Cold War priorities,[10] while Kojevnikov refers to 'physicists' skill – or luck – in playing the political games of Stalinism';[11] Josephson also maintains that post-war 'dramatic reversals of fortune were part and parcel of the arbitrary Stalinist system, and not merely aspects of the Cold War situation'.[12]

This paper is devoted to Soviet computing, which provides an interesting borderline case between defence-related physics and ideology-laden biology. The early history of Soviet computing aptly illustrates both the direct consequences of the Cold War in the form of militarization of research, and its more subtle intellectual and cultural influences. Both in the United States and in the Soviet Union, computers emerged as direct products of military-sponsored research, and became vital components of weapons systems.[13] The military importance of computing suggests a strong analogy with physics, but the situation was not so simple. In the United States, the popular perception of computers was largely shaped by cybernetic man–machine analogies: computers were seen as 'giant brains', while human behaviour, conversely, was often interpreted within the framework of calculation, manipulation and control.[14] In the Soviet Union, in contrast, cybernetics came under vicious attack in the wave of public campaigns aimed at eliminating Western ideological influences. Soviet computing was shaped by the interplay of the two conflicting motifs, and in this sense may reflect general trends in post-war Soviet science and technology.

I examine the history of early Soviet computing through the prism of discursive strategies of 'ideologization' and 'de-ideologization' elaborated by Soviet scientists and engineers in the context of the Cold War. These strategies are interpreted here as both rhetorical and conceptual devices developed by scientists themselves in an effort to formulate and advance their research agenda within the particular ideological discourse of the early 1950s. Although it is possible to view these strategies as 'political games of Stalinism', I argue that the rules of these games were to a large extent determined by the Cold War.

First, I analyse how Soviet scientists tried to balance the chief military and ideological priorities for Cold War science – to 'overtake and surpass' science in the capitalist countries, and to 'criticize and destroy' Western scholarship for its alleged ideological flaws. In particular, I discuss their strategy of drawing a boundary between the 'objective content' of scientific knowledge and its philosophical meaning. Ideological disputes of the early

1950s can thus be viewed not only as a clash of competing philosophical and ideological interpretations of particular theories, but also as a contest over the exact position of the boundary between science and ideology.

Then I discuss how the Soviet perception of computers was shaped by the tension between the drive to emulate American computing and the ideological controversy over cybernetic man–computer analogies. American computer advances became the subject of intense scrutiny, eager imitation and ideological critique, all at the same time. To resolve this tension, in the early 1950s Soviet computer specialists resorted to the discursive strategy of 'de-ideologization', distancing computing from cybernetics. This had profound intellectual consequences, such as limiting the field of computer uses to mathematical physics, and eliminating the prospects of biological and sociological modelling.

The ideological barriers were reinforced by military restrictions. The high demands placed on Soviet computing by the three top-priority defence programmes – nuclear weapons, ballistic missiles, and anti-missile defence – left little room for civilian applications. At the same time, the tendency toward pervasive military secrecy came into contradiction with the ideological task of exploiting the political 'display value' of computers. Rather than being guided by a single principle, the development of Soviet computing was shaped by various attempts to manipulate these diverse priorities. Like its American counterpart, Soviet computing adapted to the military and ideological context of the Cold War, even though the particular configuration of political and economic forces at play was different in each case.

In my Conclusion, I draw some general parallels between American and Soviet science in the early years of the Cold War. Instead of conceptualizing the Cold War as a clash of ideologies, I compare discursive strategies developed by scientists on both sides of the Atlantic. While the Soviet Union and the United States were declaring irreconcilable ideological differences, my analysis indicates some important similarities between the discursive strategies employed by scientists in both countries. This leads me to suggest that post-war Soviet science, often labelled 'Stalinist science' and seen as a unique product of a 'totalitarian' regime, might be better understood as a variety of Cold War science.

Balancing Military and Ideological Priorities for Cold War Science

In September 1950, Mikhail Lavrent'ev, director of the Institute of Precise Mechanics and Computer Technology in Moscow, told his subordinates that Soviet computing lagged behind the Americans by 10–15 years. He showed photos of a new high-speed American computer built for military purposes.[15] 'Our task is clear', he said:

> Within 5 years we must catch up with foreign countries. . . . We must eliminate the lag in high-speed digital computers. . . . I am confident that

> our Institute will not betray the trust of the Government and Comrade Stalin, and will overtake and surpass foreign countries.[16]

'Overtaking and surpassing' American computing did not appear to be the only mission of the Institute, however. In December 1952, one of the leaders of the Institute's Party organization formulated another responsibility for his colleagues:

> One of the most important tasks of our [Soviet] academic institutions, including our Institute, is the elimination of metaphysics and idealism from science. A deep reconstruction has occurred in the social sciences, physiology, and biology. Metaphysics and idealism in the natural, physical and mathematical sciences cannot be tolerated and must be weeded out.[17]

Soviet scientists were thus torn between two competing slogans: 'Overtake and Surpass!' and 'Criticize and Destroy!' (in the discussion below, I will refer to these as the 'first' and 'second' slogans). Presented with such divergent priorities, Soviet computer specialists now had to figure out a way to catch up with American computing, but not to fall under the spell of alien ideological influences.

In the murky waters of Cold War politics, Soviet scientists and engineers were caught between the Scylla of national defence and the Charybdis of ideological purity. On the one hand, following the first slogan, they were instructed to catch up with the West, particularly in such vital areas as nuclear physics and rocketry. In February 1946, Stalin personally formulated the chief priority for Soviet scientists: 'not only to overtake but to surpass in the near future the achievements of science beyond the borders of our country'.[18] But on the other hand, following the second slogan, Party ideologues urged them to treat Western scholarship as 'idealistic and reactionary'. In March 1949, the Politburo set the ideological priorities for the new, second edition of the *Great Soviet Encyclopedia*, urging the authors to 'criticize from the Party position modern bourgeois trends in science and technology'.[19] In May 1952, the Academy of Sciences Institute of Philosophy promised 'to criticize and destroy all reactionary philosophical trends that appear in bourgeois countries under new, modish names and spread the propaganda of a new war'.[20]

Soviet scientists and engineers faced a fundamental dilemma. Western science stood as a yardstick against which Soviet scientific progress was measured, though the same Western science was also branded in public discourse as a source of alien ideology. Both priorities featured prominently in Soviet public discourse. This created permanent unresolved tensions and considerable confusion. To 'overtake and surpass' Western science, Soviet scientists needed to borrow Western knowledge; but if they borrowed, they could be accused of 'kowtowing' before the West. Disregarding the latest Western trends, on the other hand, could be seen as a deliberate attempt to slow down Soviet science. As David Joravsky has written: 'The need to overtake and surpass the West coexisted with the need to stop kowtowing to the West, each inflaming the other'.[21]

Soviet discourse on Western science thus became saturated with paradoxes. Soviet authors often dismissed a Western-born scientific theory as bourgeois nonsense, and in the same breath claimed national priority in elaborating the very same theory. The Soviet leadership, distrustful of Soviet scientists, tended to support scientific and technological innovations only if they were recognized in the West. At the same time, Western reports were often regarded as a source of false information intended to mislead Soviet scientists and put them on the wrong track; it was assumed that if an idea were really worthy, it would not be advertised in the open press.

In the fragmented and contradictory ideological discourse of the late Stalinist period, there was no general rule for politically correct behaviour. In every particular situation, Soviet scientists had to choose between the two alternative slogans and approaches. But this was not simply a choice of rhetoric: it implied a radical change in their vision of science, and had profound epistemological implications. Those choosing the second approach viewed knowledge as ideological all the way through, and therefore regarded any scientific theory born in a capitalist society as, by definition, an expression of 'reactionary, imperialist ideology'. In contrast, those adopting the first approach did not regard Western science as an ideological threat: they assumed that scientific knowledge was 'objective', value-neutral, and universal across political borders.

The second slogan was taken up by the supporters of Trofim Lysenko in biology, who discarded much of contemporary Western knowledge and attempted to build a distinct, ideologically superior socialist science. In July 1948, Lysenko delivered his infamous address, 'On the Situation in Biological Science', in which he contrasted two 'opposing and antagonistic' trends in biology. One trend, Western-born 'Weismannism–Mendelism–Morganism', which underpinned modern genetics, he labelled unscientific, idealistic, metaphysical, reactionary, scholastic, feeble and sterile. As a healthy alternative, Lysenko put forward his own doctrine, a variation on the Lamarckian idea of the inheritance of acquired characteristics, which he praised as truly scientific, materialistic, creative, productive and progressive. Caught in a fierce battle for control over Soviet biological research and educational institutions, Lysenko painted his opponents, Soviet geneticists and evolutionary biologists, as enemies of Soviet ideology. He stressed the Western origins of their work, attacked the 'Morganists' for their alleged philosophical and ideological errors, and attached political labels to his opponents.[22]

Stalin personally edited Lysenko's address, bringing its rhetoric in line with the ideological priorities of the unfolding Cold War. Initially, Lysenko relied on the criterion of class to divide science into the 'Soviet' and 'bourgeois' kinds; this principle, popular among Soviet Marxists in the 1920s and 1930s, was by then completely obsolete. During World War II, it was supplanted by the thesis that international science was a unified enterprise, which reflected the spirit of wartime cooperation between the Allies. But the advent of the Cold War invalidated this thesis, too. Stalin went scrupulously over Lysenko's manuscript and replaced the obsolete

references to 'bourgeois' scientific theories with the terms 'idealistic' and 'reactionary'; he also substituted 'scientific' for 'Soviet' biology.[23] Stalin's revisions signalled a discursive turn from class-based analysis of science to the concept of 'two worlds – two ideologies in science', much more relevant to the tasks of Cold War propaganda.

An alternative approach toward Western science, based on the Party's first slogan, was pursued by Soviet defence physicists concerned with closing the 'nuclear gap'. The atomic bomb, then the most potent symbol of political and military power, effectively rendered legitimacy to Western physics in the eyes of Soviet officials. This may have played a decisive rôle in resolving an ideological controversy over quantum mechanics and relativity theory, stimulated by the institutional conflict between two groups of physicists from the Academy of Sciences and from Moscow University. In 1949, the Academy physicists reportedly prevented an ideological pogrom in physics by claiming the importance of these Western-born theories for the construction of nuclear weapons. The University physicists, who chose to trumpet the second slogan, found that their ideological arguments had little weight against the bomb.[24] The relationship between science and ideology in the post-war period was not fixed; it varied from discipline to discipline and was often hotly contested.

Shifting Boundaries Between Knowledge and Ideology

The followers of the two opposite approaches developed distinct discursive strategies to legitimize their views of the relationship between knowledge and ideology. Both groups drew on Marxist theory but evoked different aspects of it, and played on the complexity and inconsistency of the Soviet interpretation of Marxist philosophy of science. This interpretation paradoxically combined social constructivism (science as a product of socio-economic and political forces) with scientific realism (science as objective truth about nature).[25]

The first group, best represented by Lysenko and his followers, attempted to 'ideologize' science by translating scientific theories into an explicitly ideological language. They rendered their own theories into Marxist philosophical and political terms; the theories of their opponents, in turn, were identified with all sorts of philosophical and political deviations from Marxism. The 'ideologizers' rigorously traced their opponents' views to Western-born scientific theories, associated them with alien ideology, and made them an easy target for destructive ideological attacks. It was precisely this type of discourse that prompted historians to speak of the essential 'ideologization' of Soviet science in the late Stalinist period.

The second group aspired to 'de-ideologize' science by insisting on the value-neutral, impartial character of scientific knowledge. They ingeniously split Western scientific theories into two presumably independent parts: the ideologically neutral, objective 'core', and the ideology-laden philosophical 'shell'. The 'de-ideologizers' tried to rescue what they saw as the 'essential' elements of Western theories, while sacrificing only the 'dispensable' ones.

They freely and destructively criticized the latter, while safely adopting and further developing the former. The 'de-ideologization' strategy gradually shaped a popular image of science as a centaur with a solid body of scientific facts and a manifestly political face, socialist or capitalist.

In the early 1950s, mathematician Aleksandr Aleksandrov clearly outlined the 'de-ideologization' strategy in a series of articles in the popular magazine *Priroda* (Nature). He drew a sharp line between the 'objective content' and the 'philosophical interpretation' of scientific theories, and claimed that the content of scientific knowledge was 'independent from the social system or ideology'; it was only the general cultural meaning of scientific ideas that bore an 'imprint of society's ideology'.[26] The same mathematical theory, Aleksandrov argued, would receive different philosophical interpretations in different ideological contexts. He admitted that mathematics in bourgeois societies was in deep ideological crisis. In particular, he condemned Hilbert's formalism and Brouwer's intuitionism as two varieties of mathematical idealism, which 'detach mathematics from material reality, from practice'.[27] He explained that, in their search for the foundations of mathematics, the formalists relied on logical consistency, and the intuitionists on the mathematician's personal intuition. Soviet mathematicians, in contrast, were armed with the postulates of dialectical materialism, verified mathematical truths with practice, and were thus protected from philosophical errors. Therefore, while 'idealistic perversions' led to the crisis of mathematics in bourgeois societies, Soviet mathematics was ideologically safe. 'In a socialist society, a crisis of science is impossible', Aleksandrov declared, 'since Marxism – the ideology of socialism – is a scientific ideology and therefore, by its own nature, must be in harmony with the objective content of science'.[28] He concluded that, despite the idealistic interpretations of mathematical logic in the West, Soviet mathematicians should further develop the 'objective content' of formal mathematical logic and formal calculi, since formal logical consistency was the basis of the power of mathematical theories as instruments of science.[29]

In their defence of quantum mechanics and relativity theory from ideological critique, the Academy physicists also resorted to the 'de-ideologization' strategy. They insisted, for example, on the mathematical correctness of the uncertainty principle, but distanced themselves from the controversial Copenhagen interpretation. At the same time, they worked hard to elaborate an acceptable philosophical interpretation of quantum mechanics to bring it into harmony with dialectical materialism.[30] The 'de-ideologization' strategy also profoundly influenced contemporary Soviet writings on the history of science and technology.[31]

Different authors not only offered competing philosophical and ideological interpretations, but also disputed the exact position of the boundary between scientific knowledge and ideology. For example, the location of the physical principle of complementarity was hotly contested. Militant philosophers claimed that this principle was part of the 'philosophical interpretation', and thus belonged to their professional domain; they

argued that this principle was 'idealistic', and therefore false. The Academy physicists, on the other hand, tried to present complementarity as part of the core theory, and offered an alternative materialistic interpretation. The boundary between the scientific 'core' and the ideological 'shell' was constantly shifting back and forth, depending on who was drawing it.[32]

Remapping science – drawing a boundary between knowledge and ideology – was not only an epistemological task: it was also a political activity. It effectively delineated the spheres of authority between scientists and non-scientists, politicians and professional ideologues. Throughout Soviet history, these spheres were redefined many times, and epistemological boundaries redrawn accordingly. The relative intellectual autonomy of scientists in the early Soviet period was followed by the increasing involvement of politicians, government officials, and philosophers in resolving scientific disputes during the Stalin era.[33] Depending on the position of their Party and government patrons, competing groups of scientists constantly shifted this knowledge/ideology boundary, trying either to invite or to prevent the authorities' intervention. Because of the inherent tensions in post-war politics, this boundary could never be fixed. Perhaps all sides had a stake in maintaining this discursive flexibility, for it allowed them substantial room to manœuvre.

Drawing a boundary between knowledge and ideology in the field of computing proved particularly complicated, since the validity of various uses of computers for calculation, control, communication and scientific modelling was contested by diverse groups of hardware engineers, mathematicians, psychologists and philosophers. The computer radically transformed the conventional divisions between disciplines, blurring the boundaries between science and engineering, theory and experiment, and reality and simulation.[34] The computer, 'an amalgam of technological device and mathematical concept',[35] undermined the traditional discursive categories and placed a difficult choice before Soviet computer specialists.

Defining the Soviet Computer

The history of Soviet computing in the early years of the Cold War fully reflected the tension between the practical goal of developing modern sophisticated weapons and the ideological urge to combat alien influences. Reports about military uses of early digital computers in the USA played a dual discursive rôle in a Soviet context. On the one hand, they attracted serious attention from Soviet defence scientists and the military, and helped Soviet computing gain substantial support from top Party and government officials. On the other, Soviet ideologists found the idea of building electronic, remotely controlled automatic weapons to be a salient expression of Western imperialist ideology. The controversial discussions of man–computer analogies and the debates about 'thinking machines' in the West added an aura of ideological suspicion to the Soviet image of Western computing. In the early 1950s, those issues were also the focus of a large-scale campaign against cybernetics in the Soviet popular press. In the end,

Soviet computer specialists finessed these problems by constructing an imaginary boundary that was supposed to separate computer technology from ideology.

The first reports about electronic stored-program digital computers designed and built in Britain and the United States in the 1940s attracted great attention from Soviet mathematicians and physicists working on defence projects that required large amounts of computation. In 1946, the main Soviet mathematical journal *Advances in Mathematical Sciences* devoted a special double issue to 'mathematical machinery'. The issue featured two survey articles and two translations from English, including Vannevar Bush's account of his differential analyser.[36] Although this first publication was devoted exclusively to analogue computing, a brief note about Western advances in electronic digital computing soon appeared.[37] A complete outline of the stored-program concept was extracted from open Western sources and published in *Advances* in 1949.[38]

Additional information on Western computing may have come through intelligence channels. Collecting information on American military scientific and technological projects, along with political espionage, was one of the chief priorities of Soviet foreign intelligence. One former intelligence officer attached to the Soviet consulate in New York has recently revealed that in 1942–46 he obtained over 20,000 pages of classified documents from seven agents working at the plants and laboratories of RCA, Western Electric, Westinghouse, General Electric, and two aircraft companies, which held military contracts. The documents contained scientific and technical information on radar, sonar, computers, and other electronic equipment.[39]

Soviet defence researchers quickly translated their practical need for powerful computing machinery into the political language of 'overtaking and surpassing' Western science. In October 1947, Mikhail Lavrent'ev – the leading expert in mathematical modelling of explosions – appealed to a general meeting of the Soviet Academy of Sciences to close the gap in the area of computing, or 'machine mathematics', where the Soviet Union risked falling behind the West. 'While in the basic branches of mathematics [in the last 30 years] we have caught up with and in many areas even surpassed Western mathematics', he said, 'with respect to machine mathematics we must exert much greater efforts'. Lavrent'ev proposed the foundation of a specialized institute for applied mathematics and computer technology.[40]

Taking American computing as the standard for imitation had important ideological ramifications. The first American electronic digital computers were developed in close collaboration between military contractors and private enterprises, and subsequently made a quick transition from military computation and control to business applications.[41] The cultural perception of computers as 'giant brains', vehicles of large-scale industrial automation, and harbingers of the 'second industrial revolution' was fostered in the United States by the wide spread of cybernetic ideas. In 1948, American mathematician Norbert Wiener introduced these ideas to

a broad audience in his seminal book *Cybernetics, or Control and Communication in the Animal and the Machine*. Cyberneticians compared the human brain to the electronic digital computer both structurally and functionally, drawing parallels between thinking and computation, between human memory and computer storage, and between the all-or-none principle of operation of neurons and the yes-or-no positions of computer elements. More generally, they postulated negative feedback, used in such control devices as servomechanisms, as the fundamental mechanism of self-regulation in human physiology and society.[42] Many of the key cybernetic ideas grew out of wartime military research projects in which feedback devices were constructed to perform the functions of control and communication. Despite Wiener's personal pacifist stand after Hiroshima, his ideas were quickly appropriated by the military, while his popularization of cybernetics facilitated general acceptance of the patterns of military control and communication as models for a wide range of human activities.[43]

American cybernetics bore a distinct cultural imprint of the Cold War and itself became a vehicle of Cold War discourse. When defence scientists conceptualized the world as an arena of violent confrontation, they effectively circumscribed other forms of knowledge and alternative visions of the world.[44] In particular, as Peter Galison has argued, cybernetics, operations research and game theory made military conflict a model for our interaction with the world.[45] As Paul Edwards has shown, the cultural imagery of computers (or the 'cyborg discourse') embodied in integrated human–machine systems and artificial intelligence devices, was closely associated with the 'closed-world discourse', which reflected ideological stereotypes of the Cold War. Reified in military command-and-control systems, the two discourses intertwined to form a vision of the political and social world as a closed, computable system subject to manipulation and control.[46]

In the early 1950s, American cybernetics, with its military background and ideologically dubious man–machine parallels, became a prominent target for those Soviet scholars who chose a 'criticize and destroy' strategy. Trying to fulfil their obligations as professional 'soldiers of the ideological front', several journalists, philosophers and psychologists viciously attacked cybernetics in leading Soviet academic journals and popular press. Following ready-made precepts for the ongoing campaign against 'reactionary and idealistic' Western science, they labelled cybernetics 'mechanistic' (for allegedly reducing social and biological phenomena to mechanical processes) and 'idealistic' (for postulating the existence of non-material entities such as information, and replacing reality with mathematical formulae). They also branded cybernetics 'reactionary' (for aiming to replace class-conscious human workers with obedient machines) and 'imperialistic' (for serving the goals of the Western military establishment by helping to build automatic, remotely controlled weapons). Cybernetics was portrayed as a form of imperialist ideology, and man–computer analogies were regarded as philosophically deficient and ideologically

harmful. Ironically, the Soviet variety of the Cold War 'closed-world discourse' proved hostile to man–machine metaphors and produced extensive ideological critique of cybernetics. Despite their surface differences in ideology, the ardent American cyberneticians and the zealous Soviet critics of cybernetics viewed the world in very similar, confrontational terms.[47]

These ideological attacks on cybernetics, ironically, promoted the 'de-ideologization' of computing. Soviet computer specialists had to define the area of appropriate computer applications in such a way that it would not cross ideological barriers. They decided to sacrifice cybernetic 'philosophy', allowing it to be publicly 'criticized and destroyed' so as to preserve computing as a purely technical enterprise. Soviet critics of cybernetics only labelled as 'idealistic' the use of man–machine analogies in the life sciences and the social sciences; they did not at all object to the use of computers for automation and scientific calculations, which were seen as acceptable 'materialistic' applications. Even though cybernetics was labelled a 'pseudo-science', computers were not considered 'pseudo-machines'. On the contrary, while castigating cybernetics, Soviet critics called the invention of a computer a 'real scientific and technical achievement',[48] and argued that computers had 'great value for the most diverse phases of economic construction'.[49] Computers, they claimed, could make 'calculations of any degree of complexity in the shortest possible time',[50] being capable of 'completely flawless operation and procurement of results'.[51] While condemning military uses of computers in the West, Soviet critics enthusiastically praised the power of Soviet computers, which were expected to liberate people from 'the "dirty" mental labour' of complex and tiresome calculations.[52] Soviet authors presented 'machine mathematics' as value-neutral: in a bourgeois society, it served imperialist ideology; in a socialist country, it naturally upheld socialist values.

Computing for the Military

The primary task of the first computers in a socialist country turned out to be exactly the same as in the capitalist world – calculations for the military. Stimulated by the Cold War, the three main post-war Soviet defence programmes – nuclear weapons, ballistic missiles and anti-missile defence – came to dominate Soviet science and technology. As a result, the first Soviet electronic digital computers were utilized almost exclusively for large-scale military calculations. This heavy emphasis on military applications, in combination with the ideological controversy over the use of computers in biology and sociology, seriously undercut potential civilian uses of Soviet computers.

After Hiroshima, Stalin finally realized the military and political significance of nuclear weapons, and ordered urgent measures to close the nuclear gap. In August 1945, two extraordinary agencies were created to oversee the Soviet atomic project: political supervision was trusted to the Special Committee No. 1 under the State Defence Committee, while daily

management was assigned to the First Chief Directorate under the Council of People's Commissars. The Special Committee included leading defence scientists, as well as top politicians, members of the ruling Politburo, which underscored the political importance of this project.[53] The same management model was used in two other top-priority defence programmes: rocketry and radar. In May 1946, the USSR Council of Ministers (as the Soviet government was now called) set up the Special Committee on Jet Propulsion Technology, also known as the Special Committee No. 2, which directed the development of ballistic missiles.[54] In June 1947, the Council of Ministers created the Committee on Radiolocation, or the Special Committee No. 3, to oversee the construction of anti-missile defence systems. The Second and the Third Chief Directorates, respectively, were created for the daily management of the last two projects. All three large-scale crash programmes were strategic undertakings inspired by the Cold War, and in all three cases, the Soviets set the goal of catching up with the Americans in the shortest possible time.[55]

The three Special Committees were given virtually unlimited funding and the authority to draw material resources and manpower from any sector of the economy. Finance Ministry officials complained vainly about the 'uncontrollable financing' of the First Chief Directorate, which did not even bother to submit its accounts and reports to the Ministry.[56] At the end of 1948, the First Directorate directly employed 55,000 people (not including construction workers), and let research contracts to over 100 institutions.[57]

All three crash programmes – nuclear weapons, ballistic missiles and anti-missile defence – required large amounts of computation, and defence researchers took full advantage of their right to expropriate all resources necessary for the fulfilment of their top-priority tasks. Defence priorities clearly dominated early Soviet computing. In September 1948, the Academy of Sciences established the Institute of Precise Mechanics and Computer Technology in Moscow, which immediately received three high-priority government assignments: (1) creating a wireless system of automatic control of long-range missiles; (2) designing an electric simulator of the long-range missile; and (3) compiling ballistic tables for anti-aircraft fire.[58] The Institute also rendered computing services to various military organizations on the basis of individual contracts – for example, making calculations used in the construction of targeting systems for bomber aviation.[59]

Military needs were initially served by analogue devices, and the first experiments with electronic digital computing occurred only on the periphery of Soviet computing. The first Soviet stored-program digital computer, the Small Electronic Calculating Machine, or the MESM,[60] was completed in December 1951 by a small group of 12 designers and 15 technicians led by Sergei Lebedev, Director of the Institute of Electrical Engineering in Kiev. The MESM became the first operating stored-program computer in continental Europe.[61] The President of the Ukrainian Academy of Sciences, a biologist, who was not involved in defence

research, did not see much use for computers and gave little help to Lebedev's group.[62] In early 1952, the Automatic Computing Machine M-1, built by an even smaller group of nine designers and technicians, was put into operation in the Laboratory of Electrical Systems of the Energy Institute in Moscow. As one participant recalled, this project was carried out 'semi-legally', almost as a private 'hobby' of the laboratory head, Isaak Bruk.[63]

Soviet digital computing left the stage of pilot projects and received serious institutional and material support only when the military concluded that large-scale, high-speed calculations required in key defence research areas could be better performed by digital computers. Mikhail Lavrent'ev, who sponsored Lebedev's project, reportedly sent a personal letter to Stalin, stressing the importance of digital computing for national defence, and calling for more intensive efforts in this field.[64] Lebedev, in turn, submitted an official report, emphasizing the potential applications of the MESM for solving problems of nuclear physics, jet propulsion technology, radiolocation and aviation industry. The high speed and precision of calculations on electronic computers, he argued, made it possible to construct devices for guiding missiles by continuous calculation and real-time correction of their trajectories.[65] As soon as the MESM became operational, it was immediately used to perform urgent military calculations. In 1952–53, Moscow researchers from the Division of Applied Mathematics – an institution created specifically to render mathematical support to the design of nuclear weapons and ballistic missiles – made several extended trips to Kiev to work on the MESM.[66] Bruk, for his part, gave mathematicians from the Institute of Atomic Energy in Moscow, who were working on the design of nuclear weapons, the first use of his M-1 computer.[67]

As soon as the Soviet leadership became convinced that digital computing was vitally important for national defence, it took decisive measures in its support. In January 1950, the Soviet government adopted a secret decree, launching two independent projects to build large high-speed digital computers, one at the Academy Institute of Computer Technology, the other at the Special Design Bureau No. 245 of the Ministry of Machine-Building and Instrument Construction.[68] At Stalin's request, the decree specified the names of people personally responsible for each project. The Academy named Lavrent'ev and Lebedev, while the Ministry appointed Mikhail Lesechko and Iurii Bazilevskii to the task.[69] In March 1950, the Academy appointed Lavrent'ev Director of the Institute of Computer Technology; he soon invited Lebedev to set up a laboratory at the Institute with a staff of over 70 people, to design a new digital computer.[70] The Institute quickly received funding for 100 new positions,[71] and moved to a newly built, large facility, hastily constructed by the Academy of Sciences – a detail that clearly indicated the higher priority of computing.[72] At its inception in 1948, the entire Institute of Computer Technology consisted of only 60 people; by April 1952, Lebedev's laboratory alone had a staff of almost 150.[73] Most crucially, Lavrent'ev's long-

time political patron, Nikita Khrushchev, just appointed head of the Moscow city Party organization, promised the Institute his personal support.[74]

As soon as the Ministry of Machine-Building and Instrument Construction and the Academy of Sciences completed the first Soviet large high-speed electronic digital computers, those machines were used to perform urgent calculations for the defence researchers. In 1953, the Ministry computer, the STRELA, was installed at the Division of Applied Mathematics to help solve problems of nuclear physics and missile ballistics. In 1955, the Academy computer, the Large (High-Speed) Electronic Calculating Machine (the BESM),[75] was set up at the specially organized Computation Centre of the Academy of Sciences, where it also largely served military clients.

Mathematicians working for the atomic project not only became avid consumers of computer power, but they provided vital support in the early stages of Soviet electronic digital computing. Sergei Sobolev, Deputy Director of the Institute of Atomic Energy in charge of the mathematical calculations for the construction of nuclear weapons, became a major patron of several computer design initiatives. Constantly seeking computer power for the growing volume of calculations, he rented available computer time, helped obtain scarce electronic parts for new machines, and even commissioned the construction of new computers. Under his patronage, the Institute of Atomic Energy constructed its own small digital computer, which was put into operation in November 1953.[76] In the meantime, in 1952–53, atomic researchers became the first users of the small-size Automatic Computing Machine M-1 at the Energy Institute. Using his unlimited authority to procure any necessary resources, Sobolev helped obtain for M-1 urgently needed vacuum tubes, then in extremely short supply.[77] In 1952, Sobolev became the Chair of the Department of Computational Mathematics at Moscow State University; he also headed the University Computation Centre, where he sponsored the construction of an original ternary-system electronic digital computer.[78]

The ballistic missile programme was another major client of Soviet digital computing. To ensure the correctness of the most important calculations, defence scientists carried them out simultaneously at different computation facilities. Missile trajectories, for example, were calculated independently at the Division of Applied Mathematics and at the Ministry of Armament Experimental Design Bureau No. 1.[79] In 1952, the specialized journal *Problems of Rocket Technology (Voprosy raketnoi tekhniki)* published the Russian translation of a detailed Western review of recent advances in electronic digital computing;[80] this publication served as a basic text in the first course on computer programming at Moscow State University.[81] The first problem solved on the large high-speed computer M-2, Bruk's second electronic computer, was the calculation of thermodynamic and hydrodynamic parameters for missile design.[82]

The third major military crash programme – anti-missile defence – also pushed digital computer developments forward as fast as it could.

In the 1940s, the Deputy Chairman of the Council on Radiolocation, Engineer Vice Admiral Aksel' Berg, regularly received intelligence information on American radioelectronics, which he highly appreciated.[83] In 1953, Berg was appointed the Deputy Minister of Defence in charge of radar, and asked his subordinate Anatolii Kitov to prepare a report on Western computing.[84] Kitov's upbeat report had profound consequences. The Ministry of Defence quickly organized three military computation centres: the Computation Centre No. 1, the Navy Computation Centre and the Air Force Computation Centre. All three were equipped with the first serially produced STRELA computers.[85] The Design Bureau No. 1 of the Third Chief Directorate, which designed the anti-missile defence complex around Moscow, also received one of the first STRELA computers, thanks to the active rôle of the Bureau's chief engineer, who headed the state commission that tested the STRELA.[86] Among the first problems solved on that computer was the calculation of the dependency of the target-destruction probability on the detonation efficiency of fragmentation warheads.[87] For field tests of its anti-missile defence system, the Design Bureau No. 1 commissioned a specialized computer from the Academy Institute of Precise Mechanics and Computer Technology. This computer, the M-40, was completed in 1958 and, together with another model, M-50, formed a control complex for the first Soviet anti-missile defence system.[88] Bruk's M-2 computer was also employed to make calculations for a military research institute under Berg's command.[89]

In the 1950s, only one ostensibly civilian computer facility was organized. This was the Computation Centre of the Academy of Sciences, created by decree of the USSR Council of Ministers in February 1955. It was equipped with two large high-speed computers, one STRELA and one BESM. Even those two machines, however, were heavily utilized to perform military calculations.

In September 1955, the Academy created a special commission to resolve priority disputes over the use of its computing resources by various academic institutions.[90] Even though the commission recommended that at least 20% of the total computer time be allocated for the solution of 'general' (that is, unclassified) scientific problems, this recommendation was hardly followed.[91] The commission included only leading defence researchers, who often quietly divided the computer time among themselves. Even for military calculations alone, however, computer time was in short supply, and commission members often engaged in bitter disputes with one another. For example, in December 1955, Mstislav Keldysh, Director of the Division of Applied Mathematics and member of the commission, submitted a formal letter of disagreement with the commission's decision. He stated that the calculations performed by his Division 'have primary importance and are more important than most of the calculations performed at the Computation Centre by other organizations'. Keldysh claimed that the 140 hours of computer time allocated for the Division in December 1955 were 'clearly insufficient', and requested 'at

least 50 hours of computer time per week'.[92] Such disputes had to be resolved on a higher administrative level, and eventually lists of calculation problems and allocated computer time were reportedly submitted weekly for approval to the Chairman of the Soviet Council of Ministers, Nikolai Bulganin.[93]

Soviet digital computing, boosted by the military demand for large-scale computation, became narrowly focused on military applications. The nuclear weapons researchers led by Igor' Kurchatov, and the designers of ballistic missiles and spacecraft supervised by Sergei Korolev, used up almost all the resources of the first Soviet digital computers. The Soviet cosmonaut Georgii Grechko has recently recalled his experience of working in the mid-1950s on the BESM at the Academy Computation Centre:

> Kurchatov's people used it in the daytime and during the night Korolev's people. And for all the rest of Soviet science: maybe five minutes for the Institute of Theoretical Astronomy, maybe half an hour for the chemical industry.[94]

The Soviet view of the computer as a strategic technology, rather than a general-purpose information processor, assigned civilian science applications a subordinate rôle.

Design organizations even built different types of computers for the defence and the civilian sectors. For example, in 1958 the Institute of Precise Mechanics and Computer Technology built, for the first Soviet anti-missile defence system, the M-40 computer, operating at a speed of 40,000 operations per second, and a few months later finished the general-purpose M-20 machine, which ran only at 20,000.[95] In 1961, the *de facto* defence affiliation of the Institute was made official: it was transferred from the Academy of Sciences to the State Committee on Radioelectronics (later the Ministry of Radio Industry), one of the pivotal agencies of the military–industrial complex. Only one element of the Institute's civilian past, a front door plaque asserting the Institute's affiliation with the Academy, was preserved. It is still there.

While, in the Soviet Union in the early 1950s, computer applications were confined to top-secret calculations for the military, in the United States the computer quickly spread from the military sector to the business world. American computer manufacturers and business users reconstructed the computer, and turned it from a mere mathematical instrument into an electronic data-processing machine.[96] In the Soviet case, centralized control over the production and distribution of computers secured a virtual monopoly over computer access for the defence sector. Military and civilian computer applications were separated by an invisible 'Iron Curtain'. This barrier was indeed a product of the Cold War: it was supported, on the one hand, by the priority of military calculations and, on the other, by ideological suspicion toward cybernetics.

Computers 'De-Ideologized'

Soviet specialists in 'machine mathematics' had to walk a fine line between two mortal dangers – falling behind the West in computing, and following Western trends too closely. To avoid unwanted associations with controversial American cybernetics, they chose to 'de-ideologize' Soviet computing and place emphasis on the narrow technical functions of computing and information theory, ignoring any potential conceptual innovations. This strategy severely limited the field of prospective computer applications. The computer was legitimized in this Soviet context as a giant calculator; its capacities as a data processor for economic and sociological analysis, and as a tool for biological research, were downplayed, to avoid ideological complications.

As the anti-cybernetics campaign in the popular press was intensifying, Soviet mathematicians and computer specialists felt growing pressure to dissociate their work from the ideologically deficient cybernetic parallels between people and computers. In 1952, in a secret report on the current state of Soviet computing, Lebedev and Keldysh unequivocally distanced themselves from Western cybernetics: 'It should be noted that the bourgeois press frequently makes analogies between the functioning of a [computing] machine and the human brain. Such claims are totally absurd'.[97] Leaving cybernetics to philosophers for proper criticism and destruction, the authors portrayed computing as a purely technical enterprise which, they argued, must be guided by the 'overtake and surpass' principle. Contrasting Soviet efforts (only 3 large digital computers under construction) with American attainments (11 large computers under operation and 10 more under construction), they called for urgent measures to close the computing gap.

To facilitate the acquisition of information about Western computing, the Soviets launched a series of translations of Western computer literature, a step which was potentially problematic for obvious ideological reasons. Soviet scientific publishing, in addition to the technical mission of disseminating knowledge, had the political mission of disseminating the right ideology. In a 1954 report, the chief physics editor of the Foreign Literature Publishing House emphasized precisely this political mission:

> We must remember that we are dealing with foreign authors, in whose work one often encounters alien ideology. This ideology is expressed in the publication of books that carry propaganda of idealistic pseudo-scientific theories, in a systematic suppression of the works of Soviet scientists, or in the diminution of their significance. In editorial prefaces and comments we must protect the Soviet reader from alien ideology and defend the priority of Soviet scientists.[98]

To meet these requirements, Soviet computer specialists supplied their translations with a clever introduction, which condemned ideological 'errors' while rescuing the supposedly 'non-ideological' technical content. As a result, Western computer literature passed the censor relatively easily; for most publications, the interval between the original Western edition

and the Russian translation did not exceed two years.[99] To be on the safe side, Soviet editors also cut out from the original all ideologically dubious passages. The editor's preface to the 1952 translation of the American book *High-Speed Computing Devices* openly stated that all 'dubious analogies between people and machines in the spirit of pseudo-scientific statements of "cyberneticians" ' in the Russian version had been eliminated.[100] The editor of the Russian translation of Claude Shannon's paper on the 'Mathematical Theory of Communication' even renamed this work 'The Statistical Theory of Electrical Signal Transmission', to remove any trace of anthropomorphic analogies. The editor's preface read:

> The terminology of the statistical theory of electrical signal transmission and a number of its concepts are utilized by some foreign mathematicians and engineers in their speculations related to the notorious 'cybernetics'. For example, building upon superficial, surface analogies and vague, ambiguous terms and concepts, Wiener, Goldman, and others attempt to transfer the rules of radio communication to biological and psychological phenomena, to speak of the 'channel capacity' of the human brain, and so on. Naturally, such attempts to give cybernetics a scientistic look with the help of terms and concepts borrowed from another field do not make cybernetics a science; it remains a pseudo-science, produced by science reactionaries and philosophizing ignoramuses, the prisoners of idealism and metaphysics. At the same time, the notorious exercises of philosophizing pseudo-scientists cast a shadow on the statistical theory of electrical signal transmission with noise – a theory whose results and conclusions have great scientific and practical importance.[101]

Concerned with the ideological image of their work, Soviet computer specialists chose their terminology very carefully. For example, in 1951 Lebedev was advised by his colleague to avoid the term 'logical operations';[102] logical reasoning was viewed as a domain of philosophy, not computing. Such suspicious words as 'information', 'computer memory' and 'servomechanism' were usually replaced with the neutral technical terms 'data', 'storage' and 'tracking device'. As one Soviet scientist explained:

> . . . if we replace the word 'memory' with 'storage' or 'depot', that would not allow for the analogies drawn by Wiener and others, but these words would still have the same meaning.[103]

Behind these rhetorical feats lay the discursive strategy of 'de-ideologization': computing and information theory were portrayed as purely technical tools with no connection to the ideology-laden biological and social sciences.

Unlike Western technical publications on computing, popular books filled with philosophical and sociological speculations had little chance of being translated. The publication of the Russian translation of Wiener's *Cybernetics*, for example, was delayed for 10 years.[104] Only a handful of English-language copies of *Cybernetics* circulated within a narrow circle of Soviet control engineers and computer specialists. However, one of these

copies of Wiener's book was read in Isaak Bruk's Laboratory of Electrical Systems at the Energy Institute in Moscow, and it inspired several researchers there to think of computers in broader terms. In particular, engineer Mikhail Kartsev, who took an active part in the construction of the M-1 and M-2 computers, felt that military tasks were too narrow for these machines. In 1954, at a discussion of cybernetics at the Institute, he boldly stated: 'We are interested not so much in the military applications of mathematical machines or, more generally, new technical devices, but in their wider applications'.[105] His colleague Nikolai Matiukhin, who led the construction of the M-1, pointed specifically to economics as a very promising field for computer applications. Citing business uses of computers in the United States, he argued that 'in our country, such issues must be raised much more sharply. In a socialist society, ... the mechanization of planning with the assistance of computers can and should be pursued to the largest extent possible'.[106] The merciless logic of the military demands on Soviet computing, however, turned the careers of the two men in a very different direction from what they envisioned. In late 1957, Kartsev was appointed to lead the construction of the M-4, a specialized control computer for radar systems, later became the chief designer of a multi-processor supercomputer for an early warning system, and spent the rest of his career in military computing.[107] And in 1957, Matiukhin joined a group working on the Soviet version of SAGE, an air defence system supported by a geographically distributed computer network, and rose to become the chief designer of many computers and networks for national defence.[108] The first Soviet attempts to apply computers to economic planning occurred only in the late 1950s, when Bruk's Laboratory (now called the Institute of Electronic Control Machines under the State Economic Council) started working on the specialized computer M-5 for economic applications, and elaborated a proposal for a far-reaching price reform based on computer calculations of 'optimal' prices.[109]

Civilian computer applications were excluded not only by the heavy militarization of computing, the scarcity of computer time, and the ideological controversy around cybernetics, but even more effectively by the wall of silence and the barriers of clearance requirements built around the early Soviet computers. In the paranoid atmosphere of the Cold War, the cloud of secrecy surrounding military computing not only concealed Soviet computers from the enemy, but also created serious internal obstacles for the development of Soviet computing.

Computers: A State Secret or a 'Display Technology'?

The Cold War imposed contradictory demands on Soviet science and technology. Soviet scientists and engineers were supposed to hide significant domestic scientific and technological accomplishments from the enemy, especially if those innovations were related to national defence. Yet

they were also encouraged to show off their achievements as a matter of national prestige, and as proof of the superiority of the Soviet political system. Soviet computing was thus torn between the tendency toward pervasive secrecy and the ideological urge to exploit the political 'display value' of computers.[110]

Cold War security concerns imposed severe limits on any discussion of Soviet computing in the open press. Even the publication of basic textbooks on computing became a challenging task. In 1949, the Chairman of the Department of Computing Machines and Devices at the Moscow Mechanical Institute, Fedor Maiorov, submitted to the publisher a manuscript of his textbook, *The Electronic Calculating Solving Devices*, the first Soviet textbook on electronic computers. But the Glavlit, the government agency responsible for the preservation of state secrets in the press, refused to permit its publication. After two years of fruitless struggle, Maiorov appealed to the Science Department of the Party Central Committee. He explained that his book was based entirely on materials already published in open Soviet and foreign literature. 'Keeping in mind the necessity of strict preservation of state secrets', he wrote, 'I avoided any descriptions of the specific designs of devices produced in the USSR, any indications of the types of devices used, or their parameters'. Even though the type had been set and the proofs ready, the Glavlit held up publication, possibly in connection with the confiscation of another reference book on a similar subject. 'Fearing that something might happen', Maiorov complained, 'they refuse to publish my book too'.[111] The Science Department sent an inquiry to the Ministry of Machine-Building and Instrument Construction; the Ministry conceded that this book could be published, but only by the Military Publishing House, and as a classified publication. The Party authorities accepted the Ministry's verdict.[112]

The Ministry's insistence on secrecy restrictions may have been triggered by the ongoing competition between the Ministry and the Academy of Sciences. Since 1950, the two agencies pursued separate projects in designing a large high-speed electronic digital computer, and the prize – launching a serial production – would go to the one who finished first. Any meaningful cooperation between the Academy Institute of Precise Mechanics and Computer Technology and the Ministry Special Design Bureau No. 245 was hindered by the tendency not to share important technical information. As late as 1955, one of the Institute's engineers complained: 'We know more about foreign scientific research than about the domestic one [at the Bureau]'.[113] It was quite possible that Ministry officials simply used the classification of computer research as a pretext for hiding vital technical details from the rival programme.

Frustrated with the information blockade of Soviet computing, the Institute's Director, Lavrent'ev, made consistent efforts to breach this wall of secrecy. In August 1951, he sent a letter to the Party Central Committee, complaining about a recent article on computing in a major Soviet newspaper:

> The content of the article creates the wrong impression about the state of computer technology in the Soviet Union. Based on this article, a qualified reader abroad would have to conclude that the Soviet Union is lagging far behind in the field of computing and is presently on the level that the United States reached approximately 10 years ago.[114]

Nevertheless, the Ministry of Machine-Building and Instrument Construction chose to continue its policy of secrecy. In September 1951, the minister Petr Parshin complained to the Glavlit about the excessive coverage of the production of calculating machines by the Ministry in Soviet newspapers, magazines, on TV, radio and in movie theatres. 'All this is objectively aimed at divulging state secrets', he wrote. In particular, Parshin complained about the same newspaper article as did Lavrent'ev, only for the opposite reason – for disclosing too much about Soviet computer technology. Parshin requested severe measures to be taken so that 'without the Ministry's knowledge, no material about calculating machines be published in central or local newspapers or magazines, no programme be broadcast on radio or TV, and no footage be shown in movie theatres'.[115] Such measures were indeed granted.[116]

After Stalin's death in 1953, the ensuing transformations in the Party and government apparatus, and the beginning of greater openness in public discourse, the Academy tried again to get some publicity for the Institute's computer, the BESM. In July 1954, hoping to prove its superiority over the STRELA, the Academy declassified the existence of the BESM and its basic parameters, and soon showed it to a delegation from India.[117] The Academy also asked the permission of the Party Central Committee to announce the construction of the BESM in the media.[118] The bureaucratic structures set up during the early years of the Cold War, however, remained firmly in place even after Stalin's death, and their missions and procedures did not change much. The Party authorities routinely requested the opinion of the Ministry which, not surprisingly, voiced strong objections. It insisted that the Academy had no right to declassify its computer; this was the prerogative of a government-appointed special State Commission.[119] The Party authorities again sided with the Ministry, and a public announcement was postponed.

This case suggests, furthermore, that the policy of secrecy pursued by the Soviet state was not solely the product of Soviet isolationist ideology, but could sometimes be induced by interagency rivalry and used as a weapon of bureaucratic competition. The Cold War created political conditions in which government agencies could easily justify and employ excessive secrecy measures to their competitive advantage.

While the Ministry, trying to protect its pet project by pervasive secrecy, exploited the authorities' fear of the potential threat of espionage, the Academy sometimes appealed to another ideological stereotype: national prestige. In December 1954, Dmitrii Panov, Deputy Director of the Institute of Computer Technology, submitted to the Party Central Committee a report entitled 'On the question of classifying the existence of

electronic calculating machines in the USSR'. The report itself, naturally, was classified. Panov wrote:

> Presently electronic calculating machines are so widespread and so widely used that their existence in a technologically advanced country is presumed self-evident. To claim that in such a country as the USSR there are no electronic calculating machines would be almost the same as to claim that we do not have railroads or electricity, or that we cannot fly through the air. Under such conditions, to classify the existence of electronic calculating machines in the USSR seems to me not only wrong, but also harmful. No one anywhere would believe that we have no such machines.[120]

In addition, in an ingenious twist of the espionage argument, Panov tried to prove that security restrictions must be lifted. He argued that, because of this policy of secrecy, the Eastern bloc countries intending to develop their own computer technology would have to solicit help from the West, thus making it easier for Western spies to gain access to their scientific institutions. But Panov's report had little effect, and on the insistence of the Ministry of Machine-Building and Instrument Construction, the Soviet authorities continued to keep silence over Soviet digital computers for almost another full year. The Academy's efforts to lift the veil of secrecy over Soviet computing finally succeeded, however, with the arrival of Khrushchev's political 'thaw' in the mid-1950s. The first official announcement that the Soviet Union had built high-speed digital computers was made at the Conference on Electronic Digital Computers and Information Processing in Darmstadt, West Germany, in October 1955. The Soviet delegation disclosed some of the technical parameters of the BESM and the URAL, a new computer constructed at the Special Design Bureau No. 245.[121] Characteristically, Soviet digital computers were declassified for the foreign audience first; an announcement for the Soviet press came later.

With the change in the Soviet political climate during Khrushchev's 'thaw', the ideological meaning of cybernetics and the cultural perception of computers also radically changed.[122] Along with other victims of Stalinist repression, cybernetics was 'rehabilitated'. Having dismissed the old ideological critique of cybernetics, Soviet scientists now perceived cybernetic ideas as 'normal science'. Cybernetics, often viewed in the American context as a product of the 'militarization of the mind', in the Soviet context was translated into an ideology of liberation. A broad reformist movement among Soviet scientists challenged the dominant position of Stalinist schools in various scientific fields, under the banner of computerization and 'cybernetization' of science. Geneticists, non-Pavlovian physiologists, mathematical economists and structural linguists carved niches for themselves under the rubrics of 'cybernetic biology', 'cybernetic physiology', 'cybernetic linguistics', and so on. By linking cybernetic control to management and to government, Soviet scientists legitimized cybernetics as a reformist 'science of government'. In 1961, cybernetics was 'immortalized' in a new Party programme as one of the sciences called to play a crucial rôle in the creation of the material and

technical basis of communism. The popular press began calling computers 'machines of communism'.[123] The boundary between computing and ideology was erased as quickly as it had been fabricated.

Conclusion

Historians have traditionally viewed the 'ideologization' of science as a key characteristic of science under 'totalitarianism'. In this paper, I have argued that 'ideologization' was but one of two major trends in Soviet science in the early years of the Cold War. Soviet scientists were torn between two contradictory directives: to 'overtake and surpass' Western science, especially in defence-related fields, and to 'criticize and destroy' Western scholarship for its alleged ideological flaws. They developed two opposite discursive strategies to deal with this impasse. Some, like Lysenko and his followers, 'ideologized' science, translating scientific theories into value-laden political language. Others, among them many physicists and mathematicians, tried to 'de-ideologize' scientific knowledge by drawing a sharp line between ideology and the supposedly value-neutral 'objective content' of science. The strategy of 'de-ideologization' allowed them to borrow the 'objective content' of Western scientific theories without ideological hassle. Ironically, the Cold War created a strong incentive for Soviet scientists to portray scientific knowledge as ideologically neutral.

The proponents of the 'ideologization' and 'de-ideologization' strategies not only clashed over the ideological meaning of particular Western theories, but they contested the boundary between knowledge and ideology more generally. While politicians were building the 'Iron Curtain' between the two political worlds, Soviet scientists and engineers were busy constructing a similar barrier between the 'core' of science and the 'shell' of ideology. The 'Iron Curtain' between the two political systems often served as a mirror in which each side saw its own stereotypes about the other. Similarly, the fabricated divide between science and ideology reflected most conspicuously the social construction of value-neutrality, as exemplified by the attempted 'de-ideologization' of computing in the Soviet Union.

As I have argued, the computer, which in the West served both as an information-processing device and as a metaphor for human communication and control, was fashioned in the Soviet context as an ideologically neutral technical tool. As a result of Soviet computer specialists' 'de-ideologization' strategy, the Soviet computer was conceptualized as a giant calculator and stripped of all anthropomorphic metaphors. It duly served Soviet defence researchers, but was safely hidden from biologists and social scientists. Paradoxically, the computer was seen both as an indispensable tool for weapons design and control, and as a cultural symbol of technology freed from ideology.

The difference in the cultural meanings of computing on the two sides of the 'Iron Curtain' is indicative of the manifold ways in which the Cold War as a political, military and cultural phenomenon shaped (and to some

extent, was shaped by) the development of science and technology. This difference does not imply that one side was susceptible to political and ideological influence, while the other was not. Instead, this study suggests that the impact of the Cold War was pervasive on both sides, even though it took different forms in different political, ideological and institutional contexts. No doubt, to enrol scientists in the Cold War effort, the American and the Soviet governments resorted to very different means. Crude administrative pressure by Party/state officials and vociferous ideological campaigns across all scientific disciplines in the Soviet Union looked nothing like taking away security clearances and setting research priorities via selective funding, as in the American case. While the power of these measures may have ranged from kind invitation to gentle pushing to hard pressure, it is worth asking whether they all eventually pointed in roughly the same direction.

The question to what extent scientific knowledge is shaped by the interaction between science and political power goes beyond the particularity of Soviet science; this is a burning issue for the history of Cold War science in general.[124] Like their Soviet colleagues, American scientists also struggled with the problem of relating science to politics in a politically charged world. Some scientists, as well as Mertonian sociologists, intellectual historians and philosophers of science, similarly claimed intellectual independence of science from politics, drawing boundaries between 'pure' science and defence research, between the 'internal logic' of science and 'social factors', and between the 'disinterestedness' and 'organized skepticism' of the scientific community and the ideological commitments and dogmatism of politicians.[125] Ironically, the 'faith in the possibility of escape from politics' often combined with the 'faith in the objectivity of science as a solution to the subjectivity of politics';[126] science was viewed at the same time as an instrument for depersonalization and rationalization of policy-making, and as an ideological resource for implementing a liberal-democratic political agenda.

Moreover, the paradoxical juxtaposition of conflicting discursive strategies and the resulting fluidity of the science map was hardly a unique feature of post-war Soviet science. As sociologist Thomas Gieryn has argued more generally, scientists are often engaged in 'boundary-work', drawing rhetorical boundaries between science and non-science. In particular, in order to protect their autonomy, scientists tend to oscillate between two opposing discursive strategies:

> If the stakes are autonomy over scientists' ability to define problems and select procedures for investigating them, then science gets 'purified', carefully demarcated from all political and market concerns, which are said to pollute truth; but if the stakes are material resources for scientific instruments, research materials, or personnel, science gets 'impurified', erasing the borders or spaces between truth and policy relevance or technological panaceas.[127]

So, for example, while the Soviets shifted back and forth the boundary between knowledge and ideology, the Americans manipulated the notions

of 'basic' and 'applied' science, as leaders of the US National Science Foundation switched back and forth from the 'rhetoric of insulation' (an appeal to the supposedly apolitical character of basic science) to the 'rhetoric of relevance' (an argument for the vital importance of science for the interests of national defence).[128]

Despite the proclaimed differences in political ideologies, one also finds some significant similarities between the strategies chosen by American and Soviet scientists so as to adapt to the dominant political culture. To escape the ideological pressure of the 'Criticize and Destroy!' trend, Soviet scientists often resorted to the narrow, 'de-ideologized' vision of science under the 'Overtake and Surpass!' banner. This strategy had remarkable parallels in the American case. As Jessica Wang has argued, American scientists in the early post-war years, under the political pressure of domestic anti-communism, turned away from a rhetorical style of the progressive left, which emphasized the basic principles of civil liberty, and tended to rely instead on 'internal negotiations within government agencies to achieve more limited policy goals'.[129] These scientists' initial vision of science as an international endeavour gave way to backroom bargaining with government officials over funding of specific projects, often justified as counter-measures to the 'Soviet threat'. After Sputnik, the American slogan 'Catch up with the Russians!' completed the picture of two Cold War rivals chasing each other's tails.

While this points to a few parallels between the discursive strategies pursued by scientists on both sides of the 'Iron Curtain', a comprehensive picture of similarities and differences between American and Soviet science in the Cold War would require a thorough comparison of the changes in the institutional structures and political status of science in the two countries during that period. In the case of computing, as I have outlined it, the heavy militarization of research, the active rôle of government agencies, and the policy of pervasive secrecy seemed characteristic of both sides. Perhaps these similarities extended to a wider range of fields.

A comparison of separate literatures on American and Soviet science tentatively suggests some important similarities in the impact of the Cold War on scientific institutions and science policy in the two countries. In particular, Nikolai Krementsov regards post-war Soviet science as a unique 'Stalinist science system', characterized by the 'merging' of the scientific community and the government apparatus in terms of both institutions and individuals; the subordination of science policy to the priorities of the government; the fierce group competition both among scientists and between government agencies; and the tight administrative control over institutional structures, appointment and certification of scientific personnel, research agendas, and international and domestic scholarly communications.[130] Some of these characteristics, however, seem hardly unique. The domination of a single patron – the government – in the most promising scientific fields, the skewing of research priorities in the direction of political goals, the funding of disciplines in proportion to their utility for national defence, the encouragement of fierce international

competition, harsh security restrictions and intrusive loyalty checks, are often cited by historians studying American government-sponsored research during the Cold War.[131]

The parallel changes in the political status of science in the United States and the Soviet Union during the Cold War are also worth exploring. Walter McDougall has argued that the mobilization of science in the interest of national security resulted in the political rise of technocratic bureaucracies on both sides of the 'Iron Curtain'.[132] Historians of American science often talk about a 'strategic alliance' (Paul Hoch), 'increased integration' (Daniel Kevles) or a 'mutual embrace' (Silvan Schweber) of the military and the scientists involved in defence research.[133] Soviet historians, for their part, speak of 'the coalescence of military, government, and Party leadership' (I.V. Bystrova) and a 'symbiosis' between the Party/state apparatus and the Soviet scientific community (Nikolai Krementsov).[134] Further studies are needed to clarify the rôle of scientists in the Soviet military–industrial complex which, as Bystrova claims, constituted 'a mighty power group, which acted as a relatively autonomous force, dictating a course toward the continuation of the arms race [and] the Cold War'.[135]

Placing post-war Soviet science in the larger context of the Cold War calls into question its conventional perception as 'Stalinist science', an exclusive product of a 'totalitarian' society. Despite the different character of political, ideological and economic forces in the Soviet Union and the United States, the overarching political priorities and ideology of the Cold War, at least in some important instances, seem to have had a similar impact on research in both countries. Instead of regarding post-war Soviet science as a monstrous deviation from the ideal norms of science, one might rather see it as a particular form of academic practice in a politically charged environment. If, politically, the Cold War pushed the Soviet Union and the United States apart, in terms of scientific and technological development it may have brought them closer together.

In 1956, the book *Mathematics, Its Content, Methods, and Meaning*, whose authors' ideological vacillations I discussed in the introduction to this paper, was eventually published. Its introductory chapter made no mention of American mathematicians, except for Oswald Veblen and J.H.C. Whitehead: those two were criticized for failing to give a dialectical materialist definition of geometry.[136] The authors argued that mathematics under capitalism experienced an 'ideological crisis', which consisted in 'detaching mathematics from material reality', and falling into the trap of idealism and metaphysics. Following the strategy of 'de-ideologization', however, the authors drew a line between the philosophical errors and the core of mathematical theories:

> This [ideological] crisis does not at all mean that mathematics in the capitalist countries is totally stalled. A number of scientists, though standing on idealistic positions, have achieved important and sometimes outstanding successes in solving concrete mathematical problems and in

> elaborating new theories. Suffice to point out brilliant developments in mathematical logic.[137]

It was well known that logical research in the United States and Britain had laid a theoretical foundation for computer programming. A few years later, the American Mathematical Society translated this book into English. The translation editor acknowledged that 'the passages on the history and cultural significance of mathematical ideas' presented 'even greater difficulties than are usually associated with the translation of scientific texts'.[138] Some of these difficulties were solved simply: those sections that contained the ideological critique of mathematics in the capitalist countries were omitted from the translation. This was, however, part of a different story – one about American mathematics in the Cold War.

Manuscript Archives Consulted

In this paper, I draw on a number of archival sources. All the archives I cite are located in Moscow. In the Notes below, the main collections are coded as follows:

ARAN	Russian Academy of Sciences Archive (*Arkhiv Rossiiskoi Akademii Nauk*)
RGANI	Russian State Archive of Contemporary History (*Rossiiskii gosudarstvennyi arkhiv noveishei istorii*)
RGASPI	Russian State Archive of Socio-Political History (*Rossiiskii gosudarstvennyi arkhiv sotsial'no-politicheskoi istorii*)
TsAODM	Central Archive of Social Movements of Moscow (*Tsentral'nyi arkhiv obshchestvennykh dvizhenii Moskvy*)

Notes

I would like to thank Mark Solovey and Alexei Kojevnikov for very helpful comments and suggestions. Research for this paper was supported in part by a postdoctoral fellowship from the Dibner Institute for the History of Science and Technology, and a grant from the International Research & Exchanges Board, with funds provided by the US Department of State (Title VIII Program) and the US National Endowment for the Humanities. None of these organizations is responsible for the views expressed.

1. *ARAN*, f. 383, op. 1, d. 325, l. 51. The work was eventually published in Russian in 1956 (see note 136), and in an English translation in 1963 (see note 138). Unless otherwise noted, I am responsible for all the translations of Russian texts quoted in this paper.
2. *ARAN*, loc. cit. note 1, l. 57.
3. See Alexander Vucinich, *Empire of Knowledge: The Academy of Sciences of the USSR (1917–1970)* (Berkeley: University of California Press, 1984), esp. Chapter 4.
4. See Paul R. Josephson, ' "Projects of the Century" in Soviet History: Large-Scale Technologies from Lenin to Gorbachev', *Technology and Culture*, Vol. 36, No. 3 (July 1995), 519–59.
5. See David Holloway, 'Physics, the State, and Civil Society in the Soviet Union', *Historical Studies in the Physical and Biological Sciences*, Vol. 30, Part 1 (1999), 173–92.
6. See Loren R. Graham, *What Have We Learned About Science and Technology from the Russian Experience?* (Stanford, CA: Stanford University Press, 1998), Chapter 3.

7. See Mark B. Adams, 'Science, Ideology, and Structure: The Kol'tsov Institute, 1900–1970', in Linda L. Lubrano and Susan Gross Solomon (eds), *The Social Context of Soviet Science* (Boulder, CO: Westview Press, 1980), 173–204.
8. Nikolai Krementsov, *Stalinist Science* (Princeton, NJ: Princeton University Press, 1997), 6.
9. See Alexei Kojevnikov, 'Rituals of Stalinist Culture at Work: Science and the Games of Intraparty Democracy circa 1948', *The Russian Review*, Vol. 57, No. 1 (January 1998), 25–52.
10. In Krementsov's pointed formulation, 'had the Cold War military competition between East and West concentrated upon the development of biological weapons . . . instead of an atomic bomb, geneticists would probably not have been routed in 1948, [and] academy physicists might well have been purged in 1949': see Krementsov, op. cit. note 8, 282.
11. Alexei Kojevnikov, 'President of Stalin's Academy: The Mask and Responsibility of Sergei Vavilov', *Isis*, Vol. 87, No. 1 (March 1996), 18–50, at 49.
12. Paul R. Josephson, 'Review of Nikolai Krementsov, *Stalinist Science*', *Slavic Review*, Vol. 57 (Spring 1998), 215–16, at 216.
13. On military computing in the USA, see I. Bernard Cohen, 'The Computer: A Case Study of Support by Government, Especially the Military, of a New Science and Technology', in Everett Mendelsohn, Merritt Roe Smith and Peter Weingart (eds), *Science, Technology and the Military, Sociology of the Sciences Yearbook*, No. 12, Part 1 (Dordrecht: Reidel, 1988), 119–54; and Paul Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1996), Chapters 2 & 3. There is no systematic study of military computing in the Soviet Union. Some relevant information can be gathered from Boris N. Malinovskii, *Istoriia vychislitel'noi tekhniki v litsakh* (Kiev: Kit, 1995). Anne Fitzpatrick is currently writing a comparative history of computing in the American and Soviet nuclear weapons programmes.
14. See Edwards, op. cit. note 13, Chapters 6 & 7.
15. *TsAODM*, f. 7341, op. 1, d. 2, l. 119.
16. *TsAODM*, f. 7341, op. 1, d. 2, l. 54.
17. *TsAODM*, f. 7341, op. 1, d. 4, l. 87.
18. Iosif V. Stalin, 'Rech' na predvybornom sobranii izbiratelei Stalinskogo okruga goroda Moskvy 9 fevralia 1946 g' [1946], in Robert H. McNeal (ed.), *I.V. Stalin. Sochineniia*, Vol. 3 [XVI] (Stanford, CA: The Hoover Institution, 1967), 1–22, at 19.
19. Quoted in D.G. Nadzhafov, 'Antiamerikanskie propagandistskie pristrastiia stalinskogo rukovodstva', in Il'ia V. Gaiduk, Natal'ia I. Egorova and Aleksandr O. Chubar'ian (eds), *Stalinskoe desiatiletie kholodnoi voiny: fakty i gipotezy* (Moscow: Nauka, 1999), 134–50, at 137.
20. *ARAN*, f. 1922, op. 1, d. 538, l. 9.
21. David Joravsky, *Russian Psychology: A Critical History* (Oxford: Basil Blackwell, 1989), 406.
22. On the Lysenko controversy, see Loren R. Graham, *Science, Philosophy, and Human Behavior in the Soviet Union* (New York: Columbia University Press, 1987), Chapter 4; David Joravsky, *The Lysenko Affair* (Cambridge, MA: Harvard University Press, 1970); Krementsov, op. cit. note 8; Zhores A. Medvedev, *The Rise and Fall of T.D. Lysenko* (New York & London: Columbia University Press, 1969); and Valery N. Soyfer, trans. Leo Gruliow and Rebecca Gruliow, *Lysenko and the Tragedy of Soviet Science* (New Brunswick, NJ: Rutgers University Press, 1994).
23. Kirill Rossianov, 'Editing Nature: Joseph Stalin and the "New" Soviet Biology', *Isis*, Vol. 84, No. 4 (December 1993), 728–45.
24. See Vladimir P. Vizgin, 'Spasennaia dvazhdy: sovetskaia teoreticheskaia fizika mezhdu filosofiei i iadernym oruzhiem', in V.P. Vizgin (ed. and comp.), *Istoriia sovetskogo atomnogo proekta: dokumenty, vospominaniia, issledovaniia*, vyp. 1 (Moscow: Ianus-K, 1998), 329–91. Cf. Kojevnikov, op. cit. note 11, at 43–47. On the conflict between

the Academy and the University groups, see Gennadii Gorelik, 'Fizika universitetskaia i akademicheskaia', *Voprosy istorii estestvoznaniia i tekhniki* (1991), No. 1, 15–32.

25. See Kojevnikov, op. cit. note 11, 38.
26. See Aleksandr D. Aleksandrov, 'Leninskaia dialektika i matematika', *Priroda* (1951), No. 1 (January), 5–16; Aleksandrov, 'Ob idealizme v matematike' [Part I], *Priroda* (1951), No. 7 (July), 3–11; and Aleksandrov, 'Ob idealizme v matematike' [Part II], *Priroda* (1952), No. 8 (August), 3–9.
27. Aleksandrov (August 1952), op. cit. note 26, 8.
28. Ibid., 4.
29. Ibid., 9.
30. See Graham, op. cit. note 22, Chapter 10.
31. In the post-war period, historians largely gave up the Marxist sociological analysis developed in the 1920s and 1930s, and exemplified by Boris Hessen's famous 1931 paper on the social and cultural roots of Newton's *Principia*. In an attempt to protect both their subject from 'ideologization' and themselves from political complications, Soviet historians now favoured strict internalism, which lifted scientific knowledge out of its political and sociocultural context. On Soviet writings on the history and social study of science, see Slava Gerovitch, 'Writing History in the Present Tense: Cold War-Era Discursive Strategies of Soviet Historians of Science and Technology', in Christopher Simpson (ed.), *Universities and Empire: Money and Politics in the Social Sciences During the Cold War* (New York: The New Press, 1998), 189–228; and Loren R. Graham, *Science in Russia and the Soviet Union: A Short History* (Cambridge: Cambridge University Press, 1993), Chapter 7.
32. See Alexei Kojevnikov, 'Dialogues about Power and Knowledge in Totalitarian Political Culture', Section 5, 'Drawing the Boundary between Ideology and Science', paper presented at the Conference on 'Physicists in the Postwar Arena: Comparative Perspectives' (Berkeley, CA, January 1998); and Kojevnikov, op. cit. note 11, 39.
33. See Graham, op. cit. note 31, Chapter 8; and Alexei Kojevnikov, 'Dialogues about Knowledge and Power in Totalitarian Political Culture', *Historical Studies in the Physical and Biological Sciences*, Vol. 30, Part 1 (1999), 227–47. [The latter paper omits Section 5 of Kojevnikov's earlier conference paper, op. cit. note 32.]
34. See Peter L. Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago, IL & London: The University of Chicago Press, 1997), Chapter 8.
35. Michael S. Mahoney, 'The History of Computing in the History of Technology', *Annals of the History of Computing*, Vol. 10, No. 2 (1988), 113–25, at 116–17.
36. See 'Tsikl statei po matematicheskoi tekhnike', *Uspekhi matematicheskikh nauk*, Vol. 1 (1946), 3–174.
37. Mikhail L. Bykhovskii, 'Novye amerikanskie schetno-analiticheskie mashiny', *Uspekhi matematicheskikh nauk*, Vol. 2 (1947), 231–34. The next year, a somewhat more substantive article on American computing appeared: see M.L. Bykhovskii, ' "ENIAK" – Elektronnaia schetnaia mashina', *ibid.*, Vol. 3 (1948), 146–58.
38. Mikhail L. Bykhovskii, 'Osnovy elektronnykh matematicheskikh mashin diskretnogo scheta', *Uspekhi matematicheskikh nauk*, Vol. 4 (1949), 69–124.
39. Aleksandr Feklisov, *Za okeanom i na ostrove: Zapiski razvedchika* (Moscow: DEM, 1994), 105.
40. Mikhail A. Lavrent'ev, 'Puti razvitiia sovetskoi matematiki', in Sergei I. Vavilov (ed.), *Obshchee sobranie Akademii nauk SSSR, posviashchennoe tridtsatiletiiu Velikoi Oktiabr'skoi sotsialisticheskoi revoliutsii* (Moscow & Leningrad: AN SSSR, 1948), 393–402, at 402. On Lavrent'ev, see A.P. Epifanova and V.P. Il'ina (comps), *Mikhail Alekseevich Lavrent'ev: Materialy k biobibliografii* (Moscow: Nauka, 1971). He was an active participant in the nuclear weapons programme; in 1952 he was even viewed as a potential replacement for the leadership of the thermonuclear project if the first test of the Soviet hydrogen bomb was to fail: see Andrei Sakharov, *Memoirs* (New York: Alfred A. Knopf, 1990), 160–61.
41. The pattern of transferring computer applications originally created for the military to the civilian sector has continued to this day, including such highlights as artificial

intelligence and the Internet. See Janet Abbate, 'Cold War and White Heat: The Origins and Meaning of Packet Switching', in Donald Mackenzie and Judy Wajcman (eds), *The Social Shaping of Technology* (Milton Keynes, Bucks.: Open University Press, 2nd edn, 1999), 351–71; and Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1986* (Baltimore, MD: Johns Hopkins University Press, 1996).

42. Norbert Wiener, *Cybernetics, or Control and Communication in the Animal and the Machine* (Cambridge, MA: MIT Press, 1948).
43. Paul Edwards and Lily Kay have traced how cybernetics and information theory translated such patterns into new conceptual schemes for psychology, psycholinguistics and biology: see Edwards, op. cit. note 13, Chapters 6 & 7; and Lily E. Kay, 'Cybernetics, Information, Life: The Emergence of Scriptural Representations of Heredity', *Configurations*, Vol. 5, No. 1 (Winter 1997), 23–91.
44. See Ian Hacking, 'Weapons Research and the Form of Scientific Knowledge', *Canadian Journal of Philosophy*, Suppl. Vol. 12 (1986), 237–60.
45. The tracking of an enemy airplane by an anti-aircraft gunner, for example, became for Wiener a universal model for purposeful human behaviour: see Peter Galison, 'The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision', *Critical Inquiry*, Vol. 21, No. 2 (Autumn 1994), 228–66; and Philip Mirowski, 'Cyborg Agonistes: Economics Meets Operations Research in Mid-Century', *Social Studies of Science*, Vol. 29, No. 5 (October 1999), 685–718.
46. See Edwards, op. cit. note 13, esp. Chapter 1.
47. On the history of the anti-cybernetics campaign in the Soviet Union, see Slava Gerovitch, ' "Russian Scandals": Soviet Readings of American Cybernetics in the Early Years of the Cold War', *The Russian Review* (2001, forthcoming); and Lee R. Kerschner, 'Cybernetics: Key to the Future?', *Problems of Communism*, Vol. 14 (November-December 1965), 56–66.
48. Bernard E. Bykhovskii, 'Kibernetika – amerikanskaia lzhenauka', *Priroda* (1952), No. 7 (July), 125–27, at 125.
49. Materialist [pseudonym], 'Whom Does Cybernetics Serve?' [1953], trans. Alexander D. Paul, *Soviet Cybernetics Review*, Vol. 4 (1974), 31–45, at 34.
50. Teodor K. Gladkov, 'Kibernetika – psevdonauka o mashinax, zhivotnykh, cheloveke i obshchestve', *Vestnik Moskovskogo universiteta* (1955), No. 1, 57–67, at 59.
51. Materialist, op. cit. note 49, 34.
52. Boris Agapov, 'Mark III, kal'kuliator', *Literaturnaia gazeta* (4 May 1950), 2.
53. On the Soviet atomic project, see David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939–1956* (New Haven, CT: Yale University Press, 1994); and Vizgin (ed. and comp.), op. cit. note 24.
54. On Soviet rocketry, which developed in close connection with the space programme, see: James Harford, *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon* (New York: John Wiley & Sons, 1997); Walter A. McDougall, . . . *the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985); and Roger D. Launius, John M. Logsdon and Robert W. Smith (eds), *Reconsidering Sputnik: Forty Years since the Soviet Satellite* (Amsterdam: Harwood Academic Publishers, 2000).
55. On the Soviet anti-missile defence programme, see O.V. Golubev, Yu.A. Kamenskiy, M.G. Minasyan and B.D. Pupkov, 'Problems of Control and Effectiveness Evaluation in the Development of the Soviet Antimissile Defense System. 1. Experimental Proving Ground System (System A)', *Journal of Computer and Systems Sciences International*, Vol. 32 (1994), 81–88; and Grigorii Kisun'ko, *Sekretnaia zona: Ispoved' general'nogo konstruktora* (Moscow: Sovremennik, 1996). For a broad overview of the Soviet defence industry, see Nikolai S. Simonov, *Voenno-promyshlennyi kompleks SSSR v 1920–1950–e gody: tempy ekonomicheskogo rosta, struktura, organizatsiia proizvodstva i upravleniie* (Moscow: ROSSPEN, 1996).

56. I.V. Bystrova and G.E. Riabov, 'Voenno-promyshlennyi kompleks SSSR', in Vitalii S. Lel'chuk (ed.), *Sovetskoe obshchestvo: Vozniknovenie, razvitie, istoricheskii final*, Vol. 2: *Apogei i krakh stalinizma* (Moscow: RGGU, 1997), 150–208, at 162.
57. Ibid., 167.
58. *RGASPI*, f. 17, op. 132, d. 36, l. 48.
59. *RGASPI*, f. 17, op. 118, d. 758, ll. 22–23.
60. *Malaia elektronnaia schetnaia mashina*.
61. On Lebedev and his first computers, see Gregory D. Crowe and Seymour E. Goodman, 'S.A. Lebedev and the Birth of Soviet Computing', *Annals of the History of Computing*, Vol. 16. No. 1 (Spring 1994), 4–24; and Malinovskii, op. cit. note 13, 17–81.
62. Malinovskii, ibid., 42–43.
63. On Bruk and the M-1, see ibid., 175–88.
64. Ibid., 43.
65. Ibid., 67.
66. Ibid., 42.
67. Ibid., 183, 187.
68. See Sergei A. Lebedev and Mstislav V. Keldysh, 'Bol'shie schetnye matematicheskie mashiny' (1952): *ARAN*, f. 1939, op. 2, d. 2, ll. 55, 57.
69. Malinovskii, op. cit. note 13, 48. Lesechko headed the Special Design Bureau No. 245; Bazilevskii was the Bureau's chief designer.
70. *ARAN*, f. 1559, op. 1, d. 14, l. 49.
71. Archive of the Institute of Precise Mechanics and Computer Technology, 'Godovoi bukhgalterskii otchet ITMVT' (1950), l. 22.
72. *TsAODM*, f. 7341, op. 1, d. 3, l. 134.
73. *TsAODM*, f. 7341, op. 1, d. 4, l. 164.
74. *TsAODM*, f. 7341, op. 1, d. 2, l. 119. Before the war, Khrushchev led the Ukrainian Party organization and Lavrent'ev headed the Institute of Mathematics in Kiev; they then 'met many times and established a very good, friendly relationship': see R.G. Ianovskii's comments in *N.S. Khrushchev (1894–1971): Materialy nauchnoi konferentsii* (Moscow: RGGU, 1994), 164. On one occasion Khrushchev remarked: 'I have known academician Lavrent'ev for many years. He is a good scientist'; see *Pravda* (2 July 1959).
75. *Bol'shaia (Bystrodeistvuiushchaia) elektronnaia schetnaia mashina*.
76. Malinovskii, op. cit. note 13, 58.
77. Ibid., 187–88.
78. The Department of Computational Mathematics was organized in 1949; Sobolev chaired it from 1952 to 1959. The Computation Centre of Moscow University was established in 1955. See Ivan S. Berezin, trans. John Schneider, 'The Chair of Computer Mathematics and the Computation Center of Moscow University', *Soviet Cybernetics: Recent News Items*, Vol. 3 (1969), 38–44; Malinovskii, op. cit. note 13, 280–89.
79. Harford, op. cit. note 54, 220–21.
80. See Kh. Rutiskhauzer et al., 'Elektronnye tsifrovye schetnye mashiny s programmnym upravleniem', *Voprosy raketnoi tekhniki*, vyp. 2–5 (1952). This publication was a translation of Heinz von Rutishauser, Ambros Speiser and Eduard Stiefel, *Programmgesteuerte digitale Rechengerate (elektronische Rechenmaschinen)* (Basel: Birkhauser, 1951).
81. See Andrei P. Ershov and Mikhail R. Shura-Bura, trans. Ken Kennedy, 'The Early Development of Programming in the USSR', in Nicholas Metropolis, Jack Howlett and Gian-Carlo Rota (eds), *A History of Computing in the Twentieth Century* (New York: Academic Press, 1980), 137–96, esp. 154–55, 179; and Rimma I. Podlovchenko, 'O nauchnom vklade A.A. Liapunova v oblasti teorii programmirovaniia', *Problemy kibernetiki*, Vol. 32 (1977), 45–57.
82. Malinovskii, op. cit. note 13, 189–90.
83. Feklisov, op. cit. note 39, 89.

84. See Anatolii I. Kitov, 'Rol' akademika A.I. Berga v razvitii vychislitel'noi tekhniki i avtomatizirovannykh sistem upravleniia', in Vladimir I. Siforov (ed.), *Put' v bol'shuiu nauku: akademik Aksel' Berg* (Moscow: Nauka, 1988), 131–34, at 131; V. Neskoromnyi, 'Chelovek, kotoryi vynes kibernetiku iz sekretnoi biblioteki', *Komp'iuterra* (1996), No. 43 (18 November), 44–45.
85. The Computation Centre No. 1 was organized in August 1954 to carry out calculations for the design of nuclear weapons and intercontinental ballistic missiles; see '27 TsNII – stareishaia nauchnaia organizatsiia Ministerstva oborony', *Chelovek i komp'iuter* (1996), No. 21–22, 4.
86. Kisun'ko, op. cit. note 55, 277.
87. Golubev et al., op. cit. note 55, 83.
88. Malinovskii, op. cit. note 13, 68–70.
89. Ibid., 189.
90. *ARAN*, f. 471, op. 1/1947–1956, op. 1, d. 144a, l. 159.
91. *ARAN*, f. 1918, op. 1, d. 3, l. 4.
92. *ARAN*, f. 1918, op. 1, d. 3, l. 1.
93. Malinovskii, op. cit. note 13, 54.
94. Quoted in Harford, op. cit. note 54, 220.
95. Malinovskii, op. cit. note 13, 68–70.
96. Martin Campbell-Kelly and William Aspray, *Computer: A History of the Information Machine* (New York: Basic Books, 1996), Chapter 5.
97. Lebedev & Keldysh, op. cit. note 68, l. 10.
98. *ARAN*, f. 471, op. 1(47–56), d. 87a, l. 149.
99. For a list of major Soviet translations, see Ershov & Shura-Bura, op. cit. note 81.
100. Dmitrii Iu. Panov, 'Ot redaktora perevoda', in *Bystrodeistvuiushchie vychislitel'nye mashiny*, trans. from English (Moscow: Izdatel'stvo inostrannoi literatury, 1952), no pagination in my notes.
101. Nikolai A. Zheleznov, 'Predislovie', in Zheleznov (ed.), *Teoriia peredachi elektricheskikh signalov pri nalichii pomekh*, trans. from English (Moscow: Izdatel'stvo inostrannoi literatury, 1953), 5–6, at 6.
102. Malinovskii, op. cit. note 13, 31.
103. Eduard A. Meerovich, in 'Obsuzhdenie doklada professora A.A. Liapunova "Ob ispol'zovanii matematicheskikh mashin v logicheskikh tseliakh" ' (1954), in Dmitrii A. Pospelov and Iakov I. Fet (eds and comps), *Ocherki istorii informatiki v Rossii* (Novosibirsk: OIGGM SO RAN, 1998), 52–83, at 64.
104. The Russian translation of Wiener's *Cybernetics* (1948) appeared in 1958.
105. 'Obsuzhdenie doklada', op. cit. note 103, 72.
106. Ibid., 75.
107. Malinovskii, op. cit. note 13, 212–31.
108. Ibid., 197–207.
109. Ibid., 192–93.
110. On the display value of large-scale Soviet technologies, see Josephson, op. cit. note 4.
111. *RGASPI*, f. 17, op. 133, d. 230, l. 156.
112. *RGASPI*, f. 17, op. 133, d. 230, ll. 155, 158.
113. *TsAODM*, f. 7341, op. 1, d. 7, l. 78.
114. *RGASPI*, f. 17, op. 133, d. 174, l. 129. The newspaper article in question was E. Obodan, 'Vychislitel'nuiu tekhniku – na sluzhbu tekhnicheskomu progressu', *Izvestiia* (28 August 1951).
115. *RGASPI*, f. 17, op. 133, d. 174, l. 138.
116. *RGASPI*, f. 17, op. 133, d. 174, l. 147.
117. *RGANI*, f. 5, op. 17, d. 458, l. 106.
118. *RGANI*, f. 5, op. 17, d. 458, l. 95.
119. *RGANI*, f. 5, op. 17, d. 458, l. 106.
120. *RGANI*, f. 5, op. 17, d. 509, l. 34.
121. Alston S. Householder, 'Digital Computers in Eastern Europe', *Computers and Automation*, Vol. 4 (December 1955), 8–9.

122. On the history of Soviet cybernetics in the Khrushchev period, see Boris V. Biriukov (ed.), *Kibernetika: proshloe dlia budushchego. Etiudy po istorii otechestvennoi kibernetiki* (Moscow: Nauka, 1989); Slava Gerovitch, 'Striving for "Optimal Control": Soviet Cybernetics as a "Science of Government" ', in Miriam R. Levin (ed.), *Cultures of Control* (Amsterdam: Harwood Academic Publishers, 2000), 247–64; Richard D. Gillespie, 'The Politics of Cybernetics in the Soviet Union', in Albert H. Teich (ed.), *Scientists and Public Affairs* (Cambridge, MA: MIT Press, 1974), 239–98; Graham, op. cit. note 22, Chapter 8; David Holloway, 'Innovation in Science – The Case of Cybernetics in the Soviet Union', *Science Studies*, Vol. 4, No. 4 (October 1974), 299–337; Kerschner, op. cit. note 47; and Pospelov & Fet (eds and comps), op. cit. note 103.
123. Viktor D. Pekelis, 'Chelovek, kibernetika i bog', *Nauka i religiia* (1960), No. 2, 25–30, at 27.
124. For diverse perspectives on the ways the Cold War affected the production of scientific knowledge in the United States, see works by Michael A. Dennis, Ronald E. Doel, Paul Forman, Peter L. Galison, Roger L. Geiger, Bruce W. Hevly, Daniel J. Kevles, Stuart W. Leslie, Rebecca S. Lowen, Donald MacKenzie, Allan A. Needell, and essays elsewhere in this Special Issue.
125. On ideological constructions of science in the United States in the post-war period, see David A. Hollinger, 'Science as a Weapon of *Kulturkämpfe* in the United States During and After World War II', *Isis*, Vol. 86, No. 3 (September 1995), 440–54.
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127. Thomas F. Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago, IL & London: The University of Chicago Press, 1999), 23.
128. See Daniel Lee Kleinman and Mark Solovey, 'Hot Science/Cold War: The National Science Foundation After World War II', *Radical History Review*, No. 63 (Fall 1995), 110–39.
129. Jessica Wang, *American Science in an Age of Anxiety: Scientists, Anticommunism, and the Cold War* (Chapel Hill & London: University of North Carolina Press, 1999), 8–9.
130. Krementsov, op. cit. note 8, 8.
131. For a comprehensive historiographic survey, see Stuart W. Leslie, 'Science and Politics in Cold War America', in Margaret C. Jacob (ed.), *The Politics of Western Science, 1640–1990* (Atlantic Highlands, NJ: Humanities Press International, 1994), 199–233.
132. See McDougall, op. cit. note 54, esp. his Introduction.
133. For complete citations and discussion, see Leslie, op. cit. note 131.
134. I.V. Bystrova, 'Razvitie voenno-promyshlennogo kompleksa', in Vitalii S. Lel'chuk and Efim I. Pivovar (eds), *SSSR i kholodnaia voina* (Moscow: Mosgorarkhiv, 1995), 160–202, at 162; Krementsov, op. cit. note 8, 5.
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137. Ibid., 77.
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Slava Gerovitch is a postdoctoral fellow at the Dibner Institute for the History of Science and Technology in Cambridge, Massachusetts, and a research associate at the Russian Academy of Sciences Institute for the

History of Natural Science and Technology in Moscow. He is currently working on a book on the history of Soviet cybernetics; his research interests also include the history of computing and of artificial intelligence.

Address: Dibner Institute for the History of Science and Technology, E56–100, Massachusetts Institute of Technology, 38 Memorial Drive, Cambridge, Massachusetts 02139, USA; fax: +1 617 258 7483; email: slava@mit.edu