(3) THE RACE ACCELERATES

The Soviet thermonuclear program moved into high gear in 1950. What conclusions can be drawn from the program's successes in 1953 and 1955?

German A. Goncharov

No more than four days after President Harry Truman's January 1950 directive to continue US work on the superbomb, the problem of "measures to ensure the progress of RDS-6" was discussed in the USSR at a meeting of the Special Committee. On 26 February, the Council of Ministers of the USSR adopted a resolution that commissioned the First Central Administration at the Council of Ministers, Laboratory No. 2 of the Academy of Sciences, and KB-11 to organize analytical–theoretical, experimental and design operations on the construction of devices RDS-6s (*Sloika*, the Layer Cake) and RDS-6t (*Truba*, the Tube). (See the preceding article for descriptions of these thermonuclear bomb designs.)

The first priority was to build an RDS-6s with a TNT equivalent of 1 megaton and a weight of up to 5 tons. The resolution called for the use of tritium not only in RDS-6t, but also in RDS-6s. Yuli Khariton was appointed director of operations for building RDS-6s and RDS-6t, with Igor Tamm and Yakov Zel'dovich as his deputies. Tamm was to direct a new analytical–theoretical group at KB-11 to work on RDS-6s.

The resolution mandated the completion by 1 May 1952 of an RDS-6 model with a small quantity of tritium and, in June 1952, a proving-ground test of this model to verify and refine the theoretical and experimental principles. In October 1952, proposals were to be submitted for the construction of a full-scale RDS-6s, with a target date of 1954 for the device's completion.

On the same day, the Council of Ministers adopted a resolution, "Organization of Tritium Production." Resolutions to organize the production of ^{6}LiD and to construct a special-purpose reactor to boost T production followed later in 1950.

In March 1950, Andrei Sakharov and Yuri Romanov arrived for work at KB-11, and Tamm joined them in April. At the end of March, by order of Lavrenti Beria, the 1948 intelligence information on the hydrogen bomb was sent to the Academy of Sciences of the USSR in care of Sergei Vavilov to familiarize Tamm and A. S. Kompaneets with the material.

Prophetic decision

On 18 July the Scientific–Technical Council of KB-11 met to discuss the status of work on RDS-6s and RDS-6t. Another very important topic was considered: the feasibility of building an atomic bomb with a yield of several hundred kilotons, based on an improved chemical implosion technique. This proposal originated at KB-11 at the beginning of 1950. Presented at the meeting were the results of calculations demonstrating that the problem of constructing a bomb 50–100 times more powerful than RDS-1 could be solved quite rapidly by the stated approach. (RDS-1 duplicated the US Fat Man atomic bomb.) Despite needing more active fissionable materials, such a bomb was considered fully competitive with RDS-6s. This atomic bomb was subsequently assigned the code name RDS-7, and its development was completed in the first half of 1953. In contrast with the US, which carried through a similar development to a successful test in 1952, the USSR did not test its bomb. At the 1950 meeting, the council commented that development of a powerful fission bomb could not replace development of RDS-6s and RDS-6t, because the hydrogen bombs would not merely provide a large energy release, but would demonstrate the harnessing of nuclear energy of light elements in bombs—and the potential to generate virtually unlimited energy. This decision and the February resolutions set the stage for a Layer Cake with a yield in the high kiloton range. This turned out to be a prophetic decision, laying the foundation for the future construction of the substantially more efficient two-stage thermonuclear bomb design and allowing time to be gained in the race against the US. (For example, as noted in the first of these three articles, US construction of a plant to produce highly enriched ^{6}Li did not start until May 1952.)

On 17 December 1950, Khariton drafted a "Brief Report on the Status of Work on Devices of the RDS-6 Type." Referring to work on the Tube, he wrote that the problem of ignition conditions of a T–D mixture with a high percentage of T and confined within a heavy shell surrounding the active material in a gun-type bomb was being studied in detail. A positive solution was obtained for this problem. The mixture burned up rapidly and yielded a powerful stream of neutrons, which could then serve to initiate (possibly through an intermediate D zone with a small addition of T) the main D charge, provided that nuclear reactions would propagate through the charge.

Khariton's report shows why Klaus Fuchs's delivery of plans for a hydrogen bomb based on radiation implosion in the initiating chamber did not lead to an analog of the Teller–Ulam design being discovered earlier in the USSR than in the US. We see that the idea of employing an intermediate charge of a D–T mixture with a high T content to trigger nuclear reactions in the Tube was welcomed. However, it looked as though such a charge could be readily heated and compressed, and thereby ignited, by shock energy. Consequently, a configuration with a gun-type atomic bomb having a heavy, radiation-impervious outer shell was chosen as the principal design. Fuchs's configuration with a lightweight, radiation-heated

See author note on page 44.

YULI BORISOVICH KHARITON was appointed in 1950 director of operations for building the first Soviet thermonuclear devices. (All photos, and image on page 58, courtesy of RFYaTs–VNIIÉF.)

shell (the beryllium oxide tamper), being more complex, was relegated to backup status and was not subjected to analytical study. American scientists, conversely, began in October 1949 to intensify their investigation of such a design and adopted it as the main basis in choosing the structure of the experimental Cylinder device of the George test. However, the delay in discovering a Teller–Ulam analog in the USSR was offset by the development of the Layer Cake. Nevertheless, despite successful progress on RDS-6s, by 1951 it had become clear that the goal of testing an RDS-6s model in 1952 was unrealistic. On 29 December 1951, the Council of Ministers adopted a resolution stipulating measures to ensure the development, fabrication and testing of an RDS-6s model in March 1953.

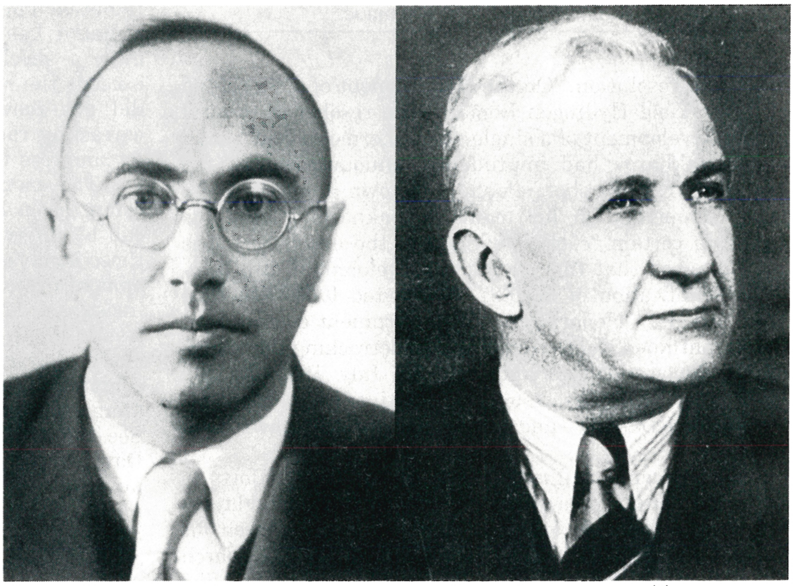
While work on the construction of the RDS-6s model advanced, the US tested the large-yield thermonuclear device called Mike on 1 November 1952. The reaction of the Soviet political leadership is interesting. On 2 December, Beria sent a memo to the First Central Administration and to Kurchatov, stating in particular: "I. V. Kurchatov: The solution of the problem of the construction of RDS-6s is of paramount importance. Judging from certain data transmitted to us, tests related to devices of this type have been conducted in the US. You are to go with A. P. Zavenyagin to KB-11 and apprise Yu. B. Khariton, K. I. Shchelkin, N. L. Dukhov, I. E. Tamm, A. D. Sakharov, Ya. B. Zel'dovich, E. I. Zababakhin, and N. N. Bogolyubov that we need to marshal every effort to ensure the successful completion of scientific-research and experimental-design operations associated with RDS-6s. You will also convey this matter to L. D. Landau and A. I. Tikhonov."

The first thermonuclear *weapon*

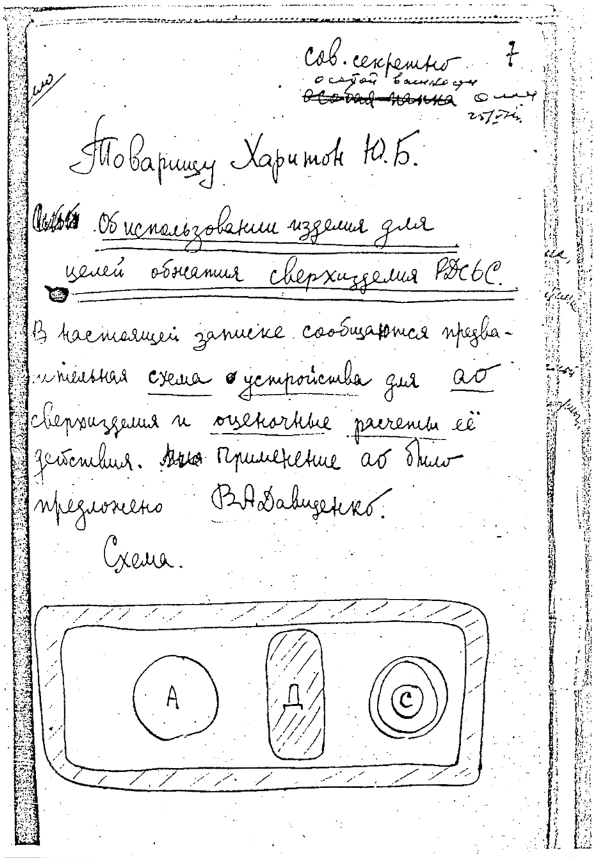
On 15 June 1953, Tamm, Sakharov and Zel'dovich signed the final report on the development of a model RDS-6s. The predicted energy release was 300 ± 100 kilotons. The model was tested on 12 August 1953; it was the fourth shot in the Soviet nuclear test series. (See the cover of this issue.) The test of the RDS-6s charge (immediately following the shot, it was named model RDS-6s) was an event of unprecedented significance in the history of thermonuclear weapons construction in the USSR and a very important step in the evolution of the Soviet nuclear weapons program. The energy release from RDS-6s was measured to be about 400 kilotons, the maximum expected power.

An important aspect was that the RDS-6s charge was made in the form of a deliverable bomb, compatible with means of conveyance; that is, it was the first prototype of a thermonuclear *weapon*. Also, the RDS-6s was designed to accommodate eventual mass production. But the main significance was that the efforts put into RDS-6s had created a scientific and engineering undertaking that would guarantee further progress in thermonuclear weapons construction in the USSR. This undertaking was promptly put to use in developing the incomparably more sophisticated two-stage thermonuclear bomb configuration, and it truly accelerated that bomb's creation. But the road to a two-stage design was a bumpy one. The main difficulty was that, although the general concept of preliminary compression of the Layer Cake by a secondary atomic explosion had been enunciated by Sakharov back in the first month of 1949, it was still not clear how this concept was to be implemented. This difficulty was further exacerbated by a circumstance that affected the whole course of the program.

On 20 November 1953, the Council of Ministers



YAKOV BORISOVICH ZEL'DOVICH (LEFT) AND IGOR EVGENIEVICH TAMM were appointed deputies to Yuli Khariton. Zel'dovich had led a team of theorists in studying the thermonuclear problem since 1946. Tamm had led a parallel group, which included Sakharov, since 1948.


Сов. секретно 7
особой важности
~~Особая папка~~
Товарищу Харитон Ю.Б.
Об использовании изделия для целей обжатия сверхизделия РДС6С.
В настоящей записке сообщается предварительная схема устройства для АО сверхизделия и оценочные расчеты её действия. Применение АО было предложено В.А.Давиденко.
Схема.

FIRST PAGE OF A JANUARY 1954 REPORT by Zel'dovich and Sakharov. The text reads: "Top Secret. Special dossier. To Comrade Khariton Yu. B. About using the gadget [atomic bomb] for implosion of the supergadget RDS-6s. This report presents a preliminary schematic of a device for the AO [atomic implosion] of the supergadget and calculations evaluating its performance. The application of AO was proposed by V. A. Davidenko. The schematic."

adopted a resolution, "On the Development of a New Type of Large-Yield Hydrogen Bomb." The resolution focused on the development of a single-stage thermonuclear bomb, which Sakharov had imprudently announced after the successful RDS-6s shot. Pushing his own proposal, as he later commented in his memoirs, Sakharov placed his hopes on certain "exotic" features of the design. It was soon realized that this avenue of development of a powerful modification of RDS-6s, designated RDS-6sD, held little promise. Nonetheless, the government decree mandated continued work on RDS-6sD, sidetracking the efforts of the theoreticians. Not until 19 July 1955 did the Council of Ministers issue a resolution postponing the testing of RDS-6sD—and in the end, testing never took place.

The growing confirmation of the futility of efforts to boost the RDS-6s energy release by compressing its layers with a conventional explosion intensified the search for ways to implement a two-stage configuration. The search for such ways began back in 1952 prior to the US Mike test. The 1953 operations plan for Zel'dovich's theoretical sector, drafted in January 1953, included a section, "Feasibility Study of the Use of Conventional RDS to Compress a High-Power RDS-6s (Atomic Compression)." The plan noted that this work was to be carried out concurrently with Tamm's sector.

Drained of enthusiasm

In 1953, A. P. Zavenyagin and D. A. Frank-Kamenetskii submitted original plans for two-stage thermonuclear charges designed to utilize the material component of the energy of a primary atomic explosion. The pivotal event that motivated the redirection of effort to the development of a two-stage configuration was the decision to abandon work on the Tube. This decision was formulated in December 1953 at KB-11 and was given final approval in a conference held at the beginning of 1954 at the Ministry of Medium Machine Building. The decision was based on the combined analytical and theoretical results obtained by the groups working under Zel'dovich at the Institute of Chemical Physics, Tamm at the Physics Institute, Lev Davidovich Landau at the Institute of Physical Problems, Pomeranchuk at the Institute of Theoretical and Experimental Physics and D. I. Blokhintsev at the Physics and Power Institute. The Zel'dovich and Pomeranchuk groups contributed decisively in the final stage of research proving nuclear detonation was impossible in the Tube.

On 14 January 1954, Zel'dovich and Sakharov sent Khariton a memo that contained a schematic of a two-stage thermonuclear charge and estimated its performance. The thermonuclear charge contained two units enclosed in a massive casing: a primary atomic bomb and a secondary thermonuclear core. The memo proposed that when the atomic bomb detonated, gases would flow from that chamber into the zone where the thermonuclear unit was located, creating enough pressure to compress it. Included in the description of the physical processes involved was the statement, "We disregard the first period—the propagation of energy in [the primary atomic bomb]; in this period more than half the energy initially comprises radiation energy and propagates by the mechanism of radiative heat conduction; by the end of the period, however, a shock wave is generated with a velocity that exceeds the rate of radiation diffusion." Thus, the memo did not show any understanding of the possibility of extracting radiation from the atomic bomb and using it to compress the thermonuclear unit.

The memo acknowledged that "the use of atomic compression has been proposed by V. A. Davidenko." It can be inferred from documents and the recollections of those involved that Davidenko's contribution to the development of the atomic compression concept was his urgent insistence, beginning in 1952, on making theoreticians aware of the need to develop a two-stage thermonuclear charge configuration. (Recall that the main idea of precompressing the Layer Cake by detonating an auxiliary atomic charge was enunciated by Sakharov back in 1949. See the previous article.) Not to be overlooked also is Davidenko's contribution to the proposal of the specific physical scheme discussed in the Zel'dovich–Sakharov memo. (Zavenyagin and Frank-Kamenetskii investigated other schemes.) However, despite the simplicity of the configuration discussed in that memo, there were serious doubts as to its workability. As seductive as the notion of a two-stage configuration was, the theoreticians expected enormous difficulties in trying to implement it by the approach being considered, and this drained them of any optimism or enthusiasm.

A sensational new principle

Accounts of a new and powerful US explosion on 1 March 1954 (the Bravo test) renewed the drive of Soviet scientists to search for ways to devise an effective, large-yield thermonuclear bomb configuration. The test bore witness to major US advances in thermonuclear weapons development and the entry of the American thermonuclear program into a new phase. It was finally clear that an effective construction technique did exist and that it had been discovered by American scientists. The technique could not have been an elaboration of the now-defunct Tube or a single-stage configuration of the RDS-6s type. The only thing left was a two-stage scheme. Intensive analytical dissection and interpretation of all the available information and cumulative experience paid off. A new compression mechanism—compression of the secondary thermonuclear core by radiation energy from a primary atomic bomb—was discovered. This discovery took place in March and April 1954.

The genesis of the new principle was hailed by KB-11 personnel as a sensation. It was immediately apparent that awesome prospects had opened up. There were not only prospects for building highly effective thermonuclear charges with extremely diverse characteristics, but also broad horizons for new research in a branch of theoretical physics of utmost interest: the physics of high pressures and high temperatures. The KB-11 team of theoreticians threw themselves into the work with unbridled enthusiasm. Instructions to confirm the possibility of radiation emission from a primary atomic bomb were sent to the Applied Mathematics Branch of the Mathematics Institute. Future work was to be based on a scheme analogous to that in the Zel'dovich–Sakharov memo, but now with energy transferred from the primary to the secondary unit by propagation of radiation. To confirm that the secondary thermonuclear unit would work using radiation implosion, it was necessary to solve a number of delicate problems associated with the description of the physical processes involved in the interaction of radiation with matter. A major contribution here was Sakharov's work, finding self-similar solutions of the partial differential equations. These self-similar solutions enabled him to obtain estimates that supported the feasibility of building a workable structure.

Research efforts on the new construction principle, an analog of the Teller–Ulam concept, began and moved forward at KB-11 too rapidly for documents or scientific reports of a priority nature to be published. The only document from this period that sheds any light on the issues of priority is a report on the activity of theoretical sector No. 1 in the first half of 1954. This report, signed by Sakharov and Romanov on 6 August, contains the following under the heading "Atomic Compression":

> Atomic compression is being investigated theoretically in collaboration with members of sector No. 2. The main problems associated with atomic compression are in the developmental stage:
>
> (1) Emission of radiation from the atomic bomb used to compress the main body. Calculations show that for [deleted] radiation is emitted very strongly. . . .
>
> (2) Conversion of radiant energy into mechanical energy to compress the main body. It is postulated [deleted]. These principles have been developed through the team effort of Sectors No. 2 and No. 1 (Ya. B. Zel'dovich, Yu. A. Trutnev, and A. D. Sakharov). . . .

The results of the escalated studies of 1954 aimed at implementing the new construction ideas in a definite structure were discussed at a meeting of KB-11's Scientific–Technical Committee on 24 December 1954, chaired by Kurchatov. The committee decided to develop an experimental thermonuclear charge to test the new principle, and to make the necessary test-site preparations in 1955.

The technical specifications for building the experimental charge were completed on 3 February 1955, at which time it was assigned the code name RDS-37. The defining stage of the analytical and theoretical support for the project had been completed by that time. Nonetheless, analytical–theoretical studies and improvement of the construction were continued right up to the final assembly and delivery of RDS-37 to the test site.

A report issued on 25 June detailed the choice of construction and the analytical–theoretical support of the RDS-37 charge. (See the box on page 61 for a list of contributors to this report.) The report's introduction, written by Zel'dovich and Sakharov, noted that the development of the new principle underlying RDS-37 was "a shining example of creative teamwork. Some contributed ideas (the project demanded an abundance of ideas, some of which were submitted independently by several authors at once). Others focused more on the formulation of methods to compute and interpret the value of various physical processes. Each and every person in the long list of project participants on the title page has played a significant role. The participation of V. A. Davidenko was extremely profitable in the discussion of the problem during its early stage (1952)."

The introduction emphasized that the development of the RDS-37 charge required enormous design-oriented, experimental and technological efforts carried out under the direction of KB-11's chief designer, Khariton. The report cited the names of many participants in this work, along with the names of the directors of teams of mathematicians, whose contribution

VIKTOR ALEKSANDROVICH DAVIDENKO is credited with proposing the use of atomic compression and urging the theoreticians to consider two-stage configurations.

to the analytical and theoretical support of RDS-37 was invaluable. (See the box.)

'The culmination of years of labor'

At the end of June 1955, the results of the analytical and theoretical groundwork for RDS-37 were reviewed in detail by a commission consisting of Tamm (the chairman), Ginzburg, Zel'dovich, M. V. Keldysh, M. A. Leontovich, Sakharov and Isaak M. Khalatnikov. The commission's summary report stated that the new principle had opened the door to entirely new possibilities for constructing thermonuclear weapons. The commission confirmed the recommendation for a proving-ground test of RDS-37.

First, a single-stage thermonuclear charge, RDS-27, was tested on 6 November 1955. This charge was a modification of the RDS-6s charge tested in August 1953. The principal difference between RDS-27 and RDS-6s was the omission of T, a measure that improved RDS-27's performance characteristics, but lowered the TNT equivalent within expected limits. The charge was assembled as an air-deliverable bomb and was dropped from an aircraft for the shot.

The splendid achievement of the Soviet thermonuclear program became known to the world on 22 November 1955, with the successful testing of the two-stage RDS-37. This charge was also assembled as an air-deliverable bomb and dropped from an aircraft. The RDS-37 was distinguished not only for the engineering solutions needed to implement the new physical principle, but also for a certain train of continuity with the 1953 RDS-6s configuration, specifically the use of ^{6}LiD. Tritium was not used in RDS-37. Special design measures were instituted to increase the likelihood that the charge would be triggered in the nominal regime. The energy release of the tested model was deliberately reduced to increase the safety of the population. Reduction was achieved by replacing some of the ^{6}LiD in the thermonuclear unit with a passive material. This replacement reduced the yield by about one half, but even this limited-yield version was a megaton-class charge. The measured energy release was in good agreement with the computational data: about 10% in excess of the most probable expected value before the test. In the words of Sakharov, "The test was the culmination of many years of labor, a triumph that has opened the way to the development of a whole range of devices with diverse high-performance characteristics (albeit not without unanticipated difficulties along the way)." The successful outcome of the first two-stage thermonuclear charge was a milestone, an epochal moment in the evolution of the Soviet nuclear weapons program.

The developments and tests of 1956 signaled the beginning of the realization of the immense possibilities afforded by the new construction principle. Modified RDS-37 charges, with several materials replaced by others better suited to mass production, were successfully tested. The first physical experiment was conducted: a nuclear explosion not with the objective of creating a specific weapon prototype, but to determine the parameters of the actual conditions created in the operation of thermonuclear charges. The first experimental steps were taken toward the construction of lighter and more efficient thermonuclear weapon prototypes. Years of hard work lay before the developers of thermonuclear weapons, years that paid off in amazing progress relative to the 1955 level of thermonuclear technology.

Conclusions: (1) The outcome of the race

The final outcome of the race between the USSR and the US to develop thermonuclear weapons was that in 1955 the USSR attained a level on a par with, and in certain aspects ahead of, the US. Among those aspects were the following:

▷ The USSR was the first to employ the highly efficient ^{6}LiD thermonuclear fuel: first in the single-stage charge of 1953 and then in the two-stage configuration of 1955. In 1952 the US tested a two-stage device using liquid D, and in 1954 it tested two-stage charges in which it was deemed necessary to use LiD with a relatively small amount of ^{6}Li. The US probably used LiD heavily enriched with ^{6}Li in thermonuclear charges in 1956.

▷ In its very first thermonuclear tests, the USSR theoretically determined the energy release with high accuracy: The predicted and measured energy release were in agreement to within about 30% in 1953 and within about 10% in 1955. The calculated and experimental values for thermonuclear charges successfully tested in the US in 1954 were off by a factor of two or more. (The low accuracy was partly attributable to the use of LiD with a high ^{7}Li content, whose nuclear properties had not been adequately investigated.)

▷ Soviet confidence in the correctness of the theoretical groundwork for even the first two-stage charge in 1955 was so strong that the USSR intentionally halved the energy release of the explosion to safeguard the population.

▷ In the two 1955 tests, the USSR was the first country in the world to airdrop thermonuclear bombs. The US made its first airdrop test of a thermonuclear bomb in 1956.

THREE PARTICIPANTS IN THE DEVELOPMENT AND TESTING OF **RDS-37,** the first Soviet two-stage bomb: German Arsen'evich Goncharov, Valentin Nikolaevich Klimov and Yurii Alekseevich Trutnev (from left to right). The photo was taken at the Semipalatinsk Test Site in November 1955, the month RDS-37 was tested.

Theoretical Contributors to RDS-37

The authors of the 25 June 1955 report detailing the choice of construction and the analytical–theoretical support of the RDS-37 charge were (in cyrillic alphabetical order) E. N. Avrorin, V. A. Aleksandrov, Yu. N. Babaev, G. A. Goncharov, Ya. B. Zel'dovich, V. N. Klimov, G. E. Klinishov, B. N. Kozlov, E. S. Pavlovskii, E. M. Rabinovich, Yu. A. Romanov, A. D. Sakharov, Yu. A. Trutnev, V. P. Feodoritov and M. P. Shumaev.

The title page of the report listed the surnames of all the theoretical physicists who had taken part in the project. Added to the authors' names were V. B. Adamskii, B. D. Bondarenko, Yu. S. Vakhrameev, G. M. Gandel'man, G. A. Dvorovenko, N. A. Dmitriev, E. I. Zababakhin, V. G. Zagrafov, T. D. Kuznetsova, I. A. Kurilov, N. A. Popov, V. I. Ritus, V. N. Rodigin, L. P. Feoktistov, D. A. Frank-Kamenetskii and M. D. Churazov.

The directors of teams of mathematicians who contributed to the analytical and theoretical support of RDS-37 were I. A. Adamskaya, A. A. Bunatyan, I. M. Gel'fand, A. A. Samarskii, K. A. Semendyaev and I. M. Khalatnikov. The general direction of the mathematical computations, which were carried out mainly at the Applied Mathematics Branch of the Mathematics Institute of the Academy of Sciences of the USSR, was assigned to M. V. Keldysh and A. N. Tikhonov.

(2) The running of the race

As early as 1945–46, Los Alamos scientists had at their disposal a wealth of ideas, which subsequently defined the entire course of US work on the thermonuclear bomb. However, the extreme complexity of the attendant physical processes and a lack of adequate analytical capabilities undeniably delayed by several years the maturation of those ideas and the discovery of the fundamental principle of thermonuclear weapon construction. The USSR caught up by acquiring intelligence information on US hydrogen bomb activities in 1945–46 and by independently discovering several key concepts (the Layer Cake, the use of ^{6}LiD and the possibility of building a several-hundred-kiloton atomic bomb without using thermonuclear materials).

By 1950 the US and USSR were on about equal footing in terms of conceptual potential. In fulfilling this potential, the USSR chose parallel development of the kiloton-range Layer Cake and a backup high-power atomic bomb (on the prophetic assumption that developing the Layer Cake would establish the prerequisites for construction of a thermonuclear bomb of virtually unlimited energy release). The US, on the other hand, took a more pragmatic course and decided against realistic development of a kiloton-range Alarm Clock in favor of an improved high-power atomic bomb. The US believed that development of the Alarm Clock, like the classical Super, would be sensible only in the megaton range, where the feasibility of building an Alarm Clock would be decidedly problematical. This "gigantomania" in the US caused a delay in the large-scale production of ^{6}LiD. In contrast, when the USSR discovered an analog of the Teller–Ulam configuration, it had everything it needed to build a thermonuclear device using ^{6}LiD.

The USSR had also established the requisite theoretical fundamentals for running calculations of the explosion of such devices. Sakharov in his memoirs had very good reason to characterize the construction of the two-stage charge in the USSR as the augmentation of the "first" and "second" ideas (the Layer Cake and the use of ^{6}LiD) with a "third" idea (compression and initiation of detonation of the thermonuclear unit by radiation energy from a primary atomic bomb). The USSR's three-year lag behind the US at the time it discovered a Teller–Ulam analog was more than closed by the successful development and testing of the Layer Cake. This course of events accounts for the Soviet successes in the race with the US. As a result, firm foundations were established for ensuring parity in the sophistication of nuclear armaments and in the subsequent progress of work on building substantially more refined thermonuclear charge prototypes.

(3) The start and the finish

The USSR's first inquiry into the possibility of using the nuclear energy of light elements was stimulated by the receipt of intelligence reports on US superbomb activities. Those reports began to arrive in 1945. As early as December 1945, the thoughts of Soviet scientists on the subject were given serious consideration, but no decisions were made about organizing Soviet superbomb research. Intelligence reports continued to arrive in the USSR during 1946–47, supplemented by announcements in the open press, including Teller's 1947 article. This set the stage for the Soviet government, on receiving in 1948 the theory documents from Fuchs describing specifics of the superbomb project, to adopt the first resolutions on organizing projects in this direction (in particular, stipulating the enlistment of the Tamm group). However, the stated objective was formulated as the "testing of existing data" on the feasibility of building a superbomb, not the actual construction of one. By mid-1949 the first recommendations had been worked out for organizing Soviet superbomb research, but the top-echelon state officials—those responsible for making decisions on nuclear energy in the name of the Soviet government—held off on making any new decisions regarding the hydrogen bomb until 31 January 1950, the date on which President Truman announced the directive to continue US superbomb work. Only after this directive did the Council of Ministers of the USSR adopt the resolution to develop a thermonuclear bomb.

The granting of high official status to hydrogen bomb construction in the US and USSR gave new impetus to the efforts of American and Soviet scientists in their push toward fulfilling the goal. However, the crowning successes of both countries in 1952–56 transcended the construction of the first deliverable thermonuclear weapon prototypes. The Teller–Ulam concept and its Soviet analog unleashed enormous possibilities for future refinements of thermonuclear weapons and undeniably opened the floodgates for the nuclear arms race between the two countries to erupt into a proliferation of nuclear weapons.

The decades of the nuclear arms race are now over, and the process of nuclear arms reduction has begun, but the negative consequences of the stockpiling have not been overcome to this day. Nonetheless, the very possession of nuclear weapons by the major powers has unquestionably made war between them impossible. And the nuclear weapons remaining in the possession of the major powers after drastic reductions should guarantee global stability and security in the world.

I am deeply grateful to the Ministry of Atomic Energy of the Russian Federation—in particular the minister, V. N. Mikhailov; the first deputy minister, L. D. Ryabev; and the chief specialist, N. I. Komov—for their support, which has made the present articles possible. I am deeply indebted to Colonel V. B. Barkovskii (ret.) and Colonel A. S. Feklisov (ret.) of the Foreign Intelligence Service of the Russian Federation, and to Consultant to the Presidential Archives of the Russian Federation A. S. Stepanov for their substantial assistance. I express heartfelt gratitude to G. Allen Greb, James G. Hershberg and Herbert F. York, who kindly furnished me with a number of nuclear history resources published in the US. ■