

LETTERS TO THE EDITORS

PACS number: **01.65.+g**

Once again on the creation of the Soviet hydrogen bomb

V B Adamskiĭ, Yu N Smirnov

Debates on whether intelligence reports were really important for the Soviet H-bomb project have flared up more than once both in the West, since Klaus Fuchs was arrested and brought to trial in Britain in 1950, and in this country since the end of the past decade. The subjects they involved have ranged widely — from the alleged value of direct information gathered by agents to speculation that Soviet nuclear scientists may have gleaned useful 'prompts' from air samples gathered after US nuclear tests.

The debates sometimes grew very heated indeed. But one thing invariably remained clear: the intelligence service played only an auxiliary role, however important it might have been [1]. US specialists, too, reasonably conclude [2] that 'to put such information [intelligence — Authors] to practical use a large and competent scientific establishment was needed, with accumulated experience and elaborate facilities in nuclear research and technology. Even then, one would not use the intelligence data to divert one's own research into entirely new directions, but merely to avoid pitfalls and blind alleys, to be sure in advance that certain things **could** work. In short, such information could permit a scientifically competent nation, well on its own way toward achieving a nuclear bomb, to accelerate somewhat its own development.'

The creation of nuclear weapons was never just a contest in science and technology between the United States and the Soviet Union, where the issues of 'who was the originator or the first' would have come to the forefront in their pure form. The sought objective had nothing to do with considerations of prestige; it stemmed from hard necessity of getting ahead of or, at least, keeping abreast of the adversary.

Therefore, the creation of nuclear weapons for the Soviet Union was not only a problem of science and technology but also a task of utmost importance for the nation. With the state efficiently pooling together all the capabilities and resources it had, these weapons were developed in the Soviet Union in a very short time.

V B Adamskiĭ All-Russian Research Institute
of Experimental Physics (VNIIEF)
607200 Sarov (Arzamas-16), Nizhniĭ Novgorod Oblast, Russia
Fax: (83130) 545-65
Yu N Smirnov Kurchatov Institute Russian Scientific Center
pl. Kurchatova 1, 123182 Moscow, Russia
Fax: (095) 943-00-73
E-mail: smirnov@qq.nfi.kiae.su

Received 15 March 1997
Uspekhi Fizicheskikh Nauk **167** (8) 899 – 902 (1997)
Translated by B V Kuznetsov; edited by S N Gorin

True, the Soviet intelligence service outwitted the US guards of atomic secrets at the time. But it would be preposterous to think that every piece of intelligence coming in from abroad would be just the morsel without which the Soviet Union could not have made a single step. What was the value of such information and what could be used in practice was quite another matter. It might have been both underestimated when received or overestimated in retrospect: for different reasons, not just any information gathered would be used. No one could say *a priori* that some particular piece of intelligence was bound to tell on Soviet research. Every instance when a piece of intelligence did work would be a great event, and such facts must be ascertained carefully and meticulously.

In view of the foregoing we feel it imperative to comment on G A Goncharov's articles describing the key events in the history of the H-bomb in the Soviet Union and in the United States, published in the October 1996 issue of *Uspekhi Fizicheskikh Nauk* [3a, b] and in the November 1996 issue of *Physics Today* [3c].

As Goncharov argues, in their work on thermonuclear weapons in 1945 – 1946, Soviet scientists were 'stimulated by the receipt of intelligence reports on US superbomb activities' [3c]. In fact, he asserts that the new data on the superbomb that Klaus Fuchs passed on to a Soviet intelligence officer in London on March 13, 1948 was an event that played 'an exceptional role in the subsequent course of the Soviet thermonuclear bomb program' [3c].† He further asserts that Fuchs' information was allegedly crucial for Soviet physicists' work on a two-stage thermonuclear charge where the main assembly would be compressed by the radiation of an atomic explosion (the radiation implosion principle). We disagree with Goncharov's assertions, but would like first to remark on three points.

First, when in 1954 the physicists at Arzamas-16 hit the path that led them to the creation, in the fall of 1955, of a two-stage thermonuclear charge which operated on the radiation implosion principle, the Soviet Union had already tested a thermonuclear weapon for the first time on August 12, 1953. Therefore, the development of a two-stage charge was a natural step for Soviet nuclear scientists to improve the thermonuclear weapon they already had. This stage in the Soviet program is the principal subject in [3]. Accordingly, our letter will mainly deal with this issue.

Secondly, Goncharov asserts that the inception of the Soviet thermonuclear program was 'stimulated by the receipt of intelligence reports.' However, it makes little sense to pick a

† Below, Goncharov's statements are cited from [3c], if ofherwise is not stated [*Authors*].

minor detail and to treat it as a 'stimulating' factor at a time when the confrontation between the United States and the Soviet Union was at its highest. The situation was such that it urged on nuclear physicists in both countries. This was further prompted by open publications of the time about the prospects of a superweapon and, the more so, by the rivalry between the two nations. It is common knowledge, for example, that the US H-bomb program was sped up after the Soviet Union tested its first atomic bomb and President Truman came up with his directive.

Moreover, when he mentions the report of I I Gurevich, Ya B Zel'dovich, I Ya Pomeranchuk, and Yu B Khariton, *Utilization of the Nuclear Energy of the Light Elements* [5], which marks the start of the Soviet thermonuclear program, Goncharov interprets it in a one-sided manner as some 'observations' which the authors set out in writing on I V Kurchatov's order in connection with intelligence reports.

In [3], Goncharov says nothing about the statement [4] made public in 1994 by Gurevich, one of the report's authors, who categorically denied that intelligence data had any impact on their report. According to Gurevich, their report was written as an unclassified document presenting a joint proposal of the four authors which they submitted to Kurchatov. The report directly stated [5]: '...[our] view on the feasibility of an explosive nuclear reaction is based on the application of the modern theory of detonation developed at the Institute of Chemical Physics.'

Thirdly, we will not comment on how correct Goncharov [3] is in reconstructing the evolution of ideas in the United States, which ultimately led to the radiation implosion principle, and the relation between 'Klaus Fuchs' proposal' and the 'Teller – Ulam configuration.' We hope US scientists themselves will speak on the matter.

Let us go back to the first point. In [3], Goncharov says that in September 1945 the Soviet intelligence service got hold of information about a two-stage design for a bomb, but atomic ('boosted' in some way) and not thermonuclear. He further asserts that Fuchs became aware of the radiation implosion principle back in the spring of 1946, when he was working in the United States: 'On 28 May 1946, Fuchs and von Neumann jointly filed a patent application for the invention of a new scheme for the initiator of the classical Super using radiation implosion.' Lastly, as Goncharov stresses [3], on March 13, 1946 Fuchs handed over 'materials of paramount importance' to a Soviet intelligence officer with information about 'the two-stage configuration operating on the radiation implosion principle.'

This implies that in the spring of 1948 nuclear physicists in both the United States and the Soviet Union were in about the same starting position regarding the underlying ideas necessary to design a thermonuclear charge operating on the radiation implosion principle. Hence, one may conclude that they already possessed the knowledge necessary to solve the problem immediately. Goncharov's assertion that the advance along that line was delayed for several years and became allegedly possible 'only by attaining a high level of mathematical modeling' is not true — 'the extraordinary complexity of the physical processes involved' did not stand in the way of doing the necessary calculations on the rather simple Mercedes calculating machines in the Soviet Union in 1954. The need for more subtle modeling, unfeasible without computers, did not arise until further improvements had to be made in thermonuclear charges and the characteristics of the structural components had to be refined.

Note that a hydrogen charge using radiation implosion was not created until the 1950s (1952 in the United States, 1955 in the Soviet Union, and 1958 in Britain). In the meantime, nuclear physicists in the United States and Britain worked through the intermediate stages in the development of such charges in 1951 and 1957, respectively, using what is known as 'boosted fission' [6].

How can one possibly insist that Fuchs' information played 'an exceptional role in the subsequent course of the Soviet thermonuclear bomb program' ('played an extraordinary role in the development of the nuclear programme in the USSR and had a considerable impact on the organization of future activities' [3b]; literally, 'kardinal'no povliyalo na organisatsiyu i khod etikh rabot' [3a]). For nothing of the kind happened either in the United States or Britain where the specialists would obviously have had the originals of the materials that had found their way into the Soviet Union. Moreover, other circumstances, and not 'Fuchs' ideas,' worked in Britain. According to British specialists, they 'analyzed the radioactive fallout after Russian tests' in 1955 and 'this led them to the idea' of radiation implosion [7].

Goncharov [3] formally, albeit painstakingly, follows the movement of the materials the Soviet intelligence service received on March 13, 1948: 'Beria ordered...,' 'an assessment of Fuchs' new materials was given by Khariton...,' 'the recommendations... formed the basis.' But Goncharov does not cite any assessments or proposals on Fuchs' materials from these documents. In fact, he admits: 'Khariton's report [of December 17, 1950 — *Authors*] '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.'† Goncharov then goes on to say: 'Thus, the memo [Zel'dovich and Sakharov submitted to Khariton on January 14, 1954 concerning Davidenko's proposal — *Authors*] did not show any understanding of the possibility of extracting radiation from the atomic bomb and using it to compress the thermonuclear unit.'

Might it not then be possible that Fuchs' information turned up for Soviet nuclear physicists to see at a later time, when they were working on an actual two-stage H-bomb design, that is, in 1954? If we turn to one of Goncharov's reports, on which he based his article [3], we read: 'The discussion of Zavenyagin's proposal and of the proposals of others [that is, specialists — *Authors*] with Zavenyagin's participation could objectively serve as a channel through which those working on the H-bomb project could learn the key intelligence information. Characteristically, when he recollects in his memoirs the history of the H-bomb based on the new principle, Sakharov refuses to discuss matters of 'who was the first and who was the originator,' but mentions only his role and that of others in the acceptance and implementation of the new idea, and in the understanding of its physical and other implications.' To bear out his point, Goncharov quotes this passage from Sakharov's memoirs: 'Several of us in the theoretical departments came up with the

† The reader should bear in mind that this refers to the materials passed on March 13, 1948, when the scheme of a real US H-bomb did not yet exist. Indeed, it was not until November 1, 1952 that the United States tested its first undeliverable thermonuclear device, and not until 1954 that the first US thermonuclear bomb was created. On the other hand, Sakharov's Sloika (Layer Cake) H-bomb ready for combat use was tested in the Soviet Union on August 12, 1953 — *Authors*).

Third Idea (the radiation implosion principle — *Authors*) at about the same time. I was one of them, and it seems to me that my early understanding of the Third Idea's physical and mathematical aspects, together with the authority I'd acquired, enabled me to play a decisive role in its adoption and implementation. True, Zel'dovich, Yuriĭ Trutnev, and others, undoubtedly made significant contributions, and they may have grasped both the promise and the problems of the Third Idea as well as did. At that time, in any case, we were all too busy (at least, I was) to worry about who received credit. Any assigning of honors at that time, moreover, would have been 'skinning the bear before it was killed.' Now it is too late to recall who said what during our discussions. And does it really matter that much?' [8].

The reader cannot but see — Sakharov's words attest to just opposite of Goncharov's assertion: Sakharov says directly that Soviet physicists worked on the problem on their own and independently. Goncharov also ignores Khariton's words: '...Soviet physicists developed the H-bomb fully independently' [9, 10]. Note also that it is unlikely that in those years Minister Malyshev could so furiously oppose the implementation of the Third Idea if it had been the product of the intelligence service. But he did and, as Sakharov recollects, brought matters to a point where Kurchatov, who supported the initiative of the Arzamas-16 nuclear physicists, received a 'strict Party reprimand' for his 'anti-state conduct' [11].

Goncharov's article gives a false idea about Zavenyagin's proposal as well. He says: 'In 1953, A P Zavenyagin and D A Frank-Kamenetskiĭ submitted original plans ('scheme' in Russian publication — *Authors*) for two-stage thermonuclear charges designed to utilize the material component of the energy of a primary atomic explosion.' This phrase could not but mislead many. His reasoning seems to be this: Since in the United States a two-stage charge was identified with a binary one and since Zavenyagin was not a physicist, his 'original scheme' was certainly the handiwork of the intelligence service. But Zavenyagin did not propose anything of the kind.

Actually, being a wise manager and wishing to make the theorists at Arzamas-16 work not only on what was known as the Sloika (Layer Cake) configuration, Zavenyagin expressed the idea in one of his talks that, much as the outer layer of conventional explosives was used to compress an atomic charge, the thermonuclear unit could be surrounded by twelve or sixteen atomic charges. Detonated all at the same time, they would compress the thermonuclear fuel to a degree beyond the capability of conventional explosives. At Arzamas-16, this straightforward, but unwieldy and naive system was immediately christened the Kandelyabr (Candelabrum) (in Goncharov's report mentioned earlier, Zavenyagin's brainchild is likewise referred to as the Candelabrum). It is very unlikely that anything of the kind (in the form of 'a candelabrum') ever existed in the files of the US project only to be stolen by Soviet spies. Historically, Zavenyagin's proposal was the first impetus that set the course of the search, although it had nothing to do with the two-stage compression scheme in its generally accepted sense.

Incidentally, the story of Zavenyagin's proposal appeared not only in [10], which was the first publication on the evolution of Soviet thermonuclear ideas and which Goncharov failed to mention. Actually, the candelabrum scheme was first disclosed nearly forty years ago [12].

Of course, any view on how important intelligence reports could be for the Soviet atomic project is interesting, provided it is well founded. Goncharov's article [3] creates only a semblance of such a foundation.

We do not intend to cast any doubt: physicists in the United States were the first to formulate and implement the idea of radiation implosion in thermonuclear charges. But Soviet physicists solved the problem independently in 1954–1955. As with any major project in science and technology, two aspects are important here: the purely scientific advancement of the undertaking, which depends on scientists, and the support of the nation's political leaders, as it assures material and administrative security.

A feasible design was finally arrived at through the evolution of ideas. But ideas live by their own law, which includes both elements of serendipity and the painstaking accumulation of scientific facts which ought not to be confused with information gathered by spies. The scheme of an H-bomb as a charge composed of two units — a primary atomic unit and a main energy-releasing unit — saw the light of day just as the evolution of ideas itself had led the designers to such a decision. Until then and until approaches which easily suggested themselves, but were flawed or held little promise in the end had exhausted themselves for various reasons, the fundamentally new, unorthodox ideas, which would later make up the mainstream, could not conquer the minds of theorists.

Looking back, we can now clearly see that work on the principal configuration of a thermonuclear charge obeyed a rigorous logic which admitted no deviation. It was only necessary to concentrate on the new course. And the logic of the transition from one stage to another called for one thing — to embark on that course and keep to its spirit. For this to happen, it was necessary to abandon unpromising side tracks of research, such as the Truba (Tube) configuration and, with some qualifications, the Layer Cake design, rather than wait for some prompts from spy reports.

Next came a continuous sequence of interrelated transitions from one stage to another until the final scheme had been developed. Because they were unquestionably obvious and straightforward, the transitions were quick or even sometimes instantaneous.

Thus, the first stage: a Layer Cake type energy-releasing unit was to be compressed, but this was now to be done by an atomic explosion rather than by a conventional explosive. The unwieldy contraption with twelve or sixteen atomic charges symmetrically girdling the Layer Cake and detonating all at the same time could hardly pass for an invention. It was, therefore, natural to use instead two atomic charges arranged on opposite sides of the energy-releasing unit (the so-called Britva (Razor) configuration which Feoktistov [13] mentions as allegedly proposed by Zavenyagin). Of course, the three charges had to be confined in a thick-walled enclosure able to hold for a split second and reflect the explosion products of the first two charges so they would compress the main thermonuclear assembly as symmetrically as possible.

The second stage. Naturally, the products of an atomic explosion have a high temperature. However, a fundamental insight was needed to appreciate the implications of the fact. It was brought forth before long. It was conjectured that the physical carrier of the temperature was the radiation invariably present in the space bounded by the enclosure in an amount proportional to the temperature.

The third stage. When it had been realized how important it would be to have an energy balance dominated by radiation inside the enclosure, it became clear that the primary charge should be arranged so that it could release a maximum amount of energy upon explosion. It was also found that the energy in the form of radiation delivered by one charge would be enough to assure both the compression and the symmetry (any asymmetry would reduce the degree of compression). This made a second atomic charge redundant at once.

As follows from the foregoing, all the links of the chain were indeed interrelated and previous ones went over into the next with no impulses from without. The entire sequence of ideas and arguments was covered in two or three months in early 1954. Then came the turn of detailed work involving closely intertwined mathematical, engineering, and technological tasks. It culminated in a successful test of the new charge on November 22, 1955.

Of course, the creation of a thermonuclear weapon was a serious and difficult problem. But not so much as to think, as Goncharov does, that this was 'one of the most perplexing challenges ever tackled in the history of mankind.' As historical experience shows, any problem in science and technology is far easier to solve, and quicker for that matter, than, say, social problems. Not that we wish to depreciate the outstanding feat of nuclear physicists in the United States and the Soviet Union. The more so that the highest award for them is the realization that the possession of nuclear weapons by the United States and the Soviet Union warded off a war between the two superpowers at the time.

In conclusion, we wish to note that V B Adamskiĭ, Yu N Smirnov and Yu A Trutnev sent a letter to *Physics Today* which carried G A Goncharov's Thermonuclear Milestones in its November 1996 issue. Quite naturally, the present publication reflects the ideas set forth in that letter.

References

1. Official Statement by the Press Bureau of the External Intelligence Service of Russia *Vestnik RAN* **64** (11) 970 – 971(1994)
2. Rabinovich E "Igor Kurchatov, 1903 – 1960: An Introduction" *The Bulletin of the Atomic Scientists* (12) 9 (1967)
3. (a) Goncharov G A "Key Events in the History of the H-bomb in the USSR and the USA." *Usp. Fiz. Nauk* **166** (10) 1095 (1996); (b) Goncharov G A "American and Soviet H-bomb Development Programmes: Historical Background." *Phys. Usp.* **39** (10) 1033 (1996); (c) Goncharov G A "Thermonuclear Milestones". *Physics Today* **49** (11) 44 (1996) Goncharov G A
4. Gershtein S S "From Recollections about Ya B Zel'dovich." *Usp. Fiz. Nauk* **161**(5) 170 (1991) [*Sov. Phys. Usp.* **34** 455 (1991)]
5. Gurevich I I, Zel'dovich Ya B, Pomeranchuk I Ya, Khariton Yu B "Utilization of the Nuclear Energy of the Light Elements." *Usp. Fiz. Nauk* **161** (5) 17 (1991) [*Sov. Phys. Usp.* **34** 351 (1991)]
6. *The Bulletin of the Atomic Scientists* (5) 48 (1993)
7. Hirsch D and Mathews W "The H-bomb: Who Really Gave Away the Secret?" *The Bulletin of the Atomic Scientists* (1/2) 22 (1990) [Translated into Russian *Usp. Fiz. Nauk* **161** (5) 171 (1991)
8. Sakharov A *Memoirs* (New York: Knopf, 1990), p. 182
9. Khariton Yu "Nuclear Weapons of the USSR: Did They Come from the USA or Were They Created Independently?" *Newspaper Izvestia* (Moscow: December 8, 1992); Khariton Yu B, Smirnov Yu N *Myths and Reality of the Soviet Nuclear Project* (Arzamas-16: VNIIEF, 1994) p. 10
10. Khariton Yu B, Adamskiĭ V B, Smirnov Yu N "On the Creation of the Soviet Hydrogen (Thermonuclear) Bomb." *Usp. Fiz. Nauk* **166** (2) 201 (1996) [*Phys. Usp.* **39** 185 (1996)]; See also Khariton Yu, Adamskiĭ V, Smirnov Yu "The Way It Was." *The Bulletin of the Atomic Scientists* **53** (1996)
11. Sakharov A *Memoirs* (New York: Knopf, 1990) p. 183
12. Concise "Encyclopedia of Nuclear Energy" [in Russian] (Ed. V S Emel'yanov) (Moscow: Bol'shaya Sovetskaya Entsikolpediya, 1958) pp. 79 – 80
13. Feoktistov L P *Paper at the HISAP-96 Conference at Dubna* (Dubna May 1996); See also Feoktistov L "The H-bomb: Who Gave Away the Secret?" *Newspaper Kurchatovets* (6) 1996 RNTs-KI p. 4