TO THE FIFTIETH ANNIVERSARY OF STARTING UP THE FIRST LINEAR ACCELERATORS AT NSC KIPT

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The USSR's first high-frequency linear accelerators of protons, electrons and multiply charged ions were designed and constructed at the Kharkov Institute of Physics and Technology, which quickly recovered with the end of German occupation and since 1946 has resumed its research work. K.D. Sinel'nikov, the then Director of the Institute, assembled a team of scientists with initiative, who began studies on linear methods of charged particle acceleration, as in the war years there appeared high-frequency generators of electromagnetic waves so needed for linear accelerators. As early as in 1947-1948 there also appeared the first theoretical developments aimed at providing a stable interaction of charged beams with the electromagnetic wave field.

Beginning from 1950 the Institute was reinforced by young specialists - graduates from a special section (opened in 1948) at the Physics-Mathematics Faculty of the Kharkov State University (KhSU). The young physicists were trained in advanced branches of physics by the KIPT specialists. Further on, that section turned into an independent KhSU Physico-Technical Faculty. The authors of the present survey are all the graduates of different years from this faculty of the KhSU. In the KhSU lecture-rooms and in the KIPT laboratories there were continuous discussions about physical transformations, electromagnetic processes, weak and strong interactions.

And only recently, when the archives of the Ministry of Middle Mechanical Engineering were disclosed, we have come to know about the second line of the activities previously impermissible for any discussions.

In fact, in those years when the country was just healing its wounds inflicted by the war, the Soviet Government allocated great funds for the development of physical science. Of course, everyone realized that it was for the nuclear energy, but why was that great attention to the accelerator physics?

And at present, marking the fiftieth anniversary of the onset of wide-scale investigations in accelerator physics, one cannot remain emotionless when reading the first decrees of the Soviet Government on the development of work to be aimed at designing and creating those accelerators. Now imagine the situation... The first post-war years, the world is divided into two camps, the former allies in the anti-Hitler coalition have become adversaries. The Unites States are the monopolist in possessing the nuclear weapons. They discuss there the plans of striking nuclear blows against the USSR, cities are chosen as first-turn targets for nuclear attack. In the USSR, all the efforts are directed to protect the country against the nuclear assault. It was natural that the main efforts were aimed at creating own atomic bomb, but there was none as yet. Different variants of repulsing the nuclear attack were being discussed, and then physicists put forward an idea of creating a new anti-aircraft weapon. On the initiative of Academician N.N. Semyonov, a future Nobel Prize winner, the proposal was formulated to create the "AAI" - a new-type anti-aircraft installation using accelerated particle beams. It may now appear incredible, but that proposal gave birth to the governmental decision, now unclassified and published in the documents concerning the "Atomic project in the USSR, part II, an atomic bomb, 1945-1954"[1].

"Decree of the USSR Council of Ministers N3092-1249, "On conduction of scientific research work to elucidate the possibility of implementing the AAI installation"

Moscow, the Kremlin 15 August, 1948

Strictly confidential
(Special briefcase)

The USSR Council of Ministers decrees:

1. To charge the Chemical Physics Institute (c. Semyonov), Institute of Physics (c. Vavilov), Laboratory N2 USSR AS (cs. Meshcheryakov and Mints) and Laboratory N1 of Physico-Technical Institute UkrSSR AS (c. Sinel'nikov) with the task to ensure over the period of 1948-1949 the fulfilment of research work associated with looking into the possibility of implementing the "AAI" according to the subject program developed by Academician Semyonov N.N.
2. To place the supervision and co-ordination of the research work on elucidation of the possibility of implementing the "AAI" on the Chemical Physics Institute (c. Semyonov).
3. To charge the Chemical Physics Institute (c. Semyonov) with the following tasks:

a) by 1 October, 1948, together with Institute of Physics (c. Vavilov), Laboratory N2 USSR AS (cs. Meshcheryakov and Mints), Laboratory N1 of Physico-Technical Institute UkrSSR AS (c. Sinel'nikov) and Committee N3 at the USSR Council of Ministers (c. Shchukin), to draw up verified programs of activities to ensure the fulfillment of the subject program of work, attached herewith;

b) to provide, within the Chemical Physics Institute power (c. Semyonov) a further theoretical development of the problems concerning the "AAI" with the use of additional data and information as they are obtained;

c) quarterly, starting from November, 1948, to submit the reports on the progress of work at the "AAI" to the USSR Council of Ministers.

4. To charge Committee N3 at the USSR Council of Ministers (c. Shchukin), the Ministry of Armaments (c. Ustinov) with the task of performing theoretical

calculation work mentioned in the Attachment under the assignment of the Chemical Physics Institute (c. Semyonov).

Chairman of the USSR
Council of Ministers I.Stalin
Business Manager
at the USSR Council of Ministers Ya.Chadayev"

Then a detailed subject program follows, where item 6) reads as:

"- Development of the design of the linear accelerator for 500 MeV deuterons and for 1 GeV protons with a sustained current of no less than 10 μA or an intermittent current of no less than 80 μA: calculations and design of the unit,

- 1948

- Construction of the type accelerator unit with a particle beam from the Van de Graaff tube and the cyclotron.

- 1949

There exists one more government decree, this being of 1954, where again the linear accelerators, including electron linacs, are involved, but now with another line of their applicability.

These documents directly concern our history and now, particularly, in connection with the jubilee, it is of interest to discuss them from two points of view.

1. Were the problems posed in those decrees realizable?
2. How will the solution of the problems posed before the Institute influence the development of the Institute itself and its workers, too?
3. Have the problems discussed 50 years ago any prospects now?

It is nowadays quite natural for each student to answer that the energy losses by the charged beam in the atmosphere are so great that nobody will ever try to "pierce" the atmosphere with accelerated particles. But is it possible that only 50 years ago our scientists did not know this truth? We think they did know, because this is the truth for both the students and the majority of scientific workers, not to say about Academicians. In our opinion, for no special reason nobody would ever try to "pierce" the atmosphere by shooting at it. If the accelerators with the parameters mentioned in the decree could be created, then another problem would arise, namely, creation of a channel in the atmosphere to pass the accelerated particles. In those years this problem was not yet discussed, but 10 - 20 years later this problem arose, though for other purposes. So, the first question can be answered as follows: the problem had no straightforward solution, because there were no accelerators with those parameters and there were no evident ways to guide the accelerated beam to the target. And nevertheless, the decree was approved and great teams of scientists appeared involved in the problem of accelerator creation.

It should be stressed that the idea of a linear charged particle accelerator was first published as early as in 1928 by the Norwegian physicist Wideroe. But in practice, it was realized in 1946 for an energy of 30 MeV by the American physicist L. Alvarez in Berkeley (Lawrence Radiation Laboratory, California University, USA).

And as soon as in 1948, the design of a similar 1000 MeV accelerator was prescribed in the government decree, the KIPT being charged with the task of the accelerator development and construction. In 1950, the 20 MeV Alvarez-type accelerator was put into operation [2], however, its parameters were more than modest (in beam current and divergence), and at once new problems arose. Some of them were immediately solved [3], others called for long-standing investigations that fell outside the scope of the problem being solved, still others remained unsolved until now. Thus, an injection energy of about 1 MeV required the development and construction of small-size accelerators-injectors. The KIPT scientists, having an experience in the development of electrostatic open-type Van de Graaff accelerators, decided to develop a pressure-insulated Van de Graaff accelerator. The first accelerator-injector of this kind was just made for the proton linear accelerator, and it has proved its worth. Based on this design, a succession of pressurized electrostatic accelerators were developed by the Yefremov Electrophysical Apparatus Institute; they were supplied to all the leading nuclear centers of the USSR. And though there is no longer that very proton accelerator at KIPT (it was taken out of service and dismantled in the sixties), the electrostatic accelerator was transformed to accelerate multiply charged ions and it got the name EhSUVI (electrostatic accelerator of multiply charged ions). The correct solution to the problem of injection into proton linear accelerators was proposed only in the seventies, when an accelerator with a uniform quadrupole magnetic focusing was built in Moscow. It has come to be known in the world as an RFQ accelerator.

Powerful vacuum pumps were specially designed at KIPT for the accelerators. Later, they served as a basis for vacuum metallurgy, too.

The particle focusing in the basic accelerator was realized with foils and grids and those focusing elements were the main obstacle on the way of obtaining high currents. Then an idea occurred to use beryllium foils as focusing foils. But the beryllium metal started to be produced in small lots by the domestic industry was brittle. A demand for plastic beryllium arose and the problem of creating such a material was solved at KIPT. True enough, by that time magnetic quadrupole lenses were proposed and developed, they started to be used throughout the world to focus protons in linear accelerators, but ductile beryllium has appeared to be of use for many other applications.

And the last. The proton accelerator is energized by meter-band electromagnetic oscillations. Generators were built on the base of lamps generally used in radar engineering, the last ones were of low power and could not provide the needed energization of high-power accelerators. In Moscow, special attention was paid to the development of new powerful radio engineering. The Radio-Technical Institute was created to meet the needs of both radar engineering and accelerator engineering. Therefore, in the late fifties, the development of high-power proton linear accelerators appeared to move to Moscow.

A new vigorous development of proton linear accelerator at KIPT took place already in the seventies, when it was proposed to create small-size proton accelerators for applied purposes, but those were quite different accelerators. The problems remain topical for the investigators to-day, though they have no longer that strong support on the part of the Government.

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