Tape 2 Side B

Successful work in this area attracted the attention of the director of the institute, and he moved me closer to himself, that is made a deputy director of the institute. The scientific responsibilities were limited to my own scientific work. As for the distribution of responsibilities that we had in the directorate, and still have, I was assigned the following tasks related to chemical physics, radiochemical physics, and the use of nuclear and plasma sources for technological purposes. This was the range of professional tasks that I was carrying out.

After Anatoly Petrovich Alexandrov was elected president of the USSR Academy of Sciences, he made me the first deputy director of the institute, entrusted me with several responsibilities regarding the management of the institute, but did not change my responsibilities in the scientific sphere. There were no new areas that I was responsible for.

As before, Eugeny Pavlovich Velikhov was fully responsible for the largest part of the institute's work: plasma physics and controlled thermonuclear fusion. Vyacheslav Dmitrievich Pismienniy was made responsible for laser technology. Lev Petrovich Feoktistov, a very intelligent and talented man, was given the responsibility of matters of nuclear physics and its special practical applications. Anatoly Petrovich had a deputy for nuclear energy earlier, Eugeny Petrovich Ryazantsev. Before him, Viktor Alekseyevich Sidorenko worked as the director of the department of nuclear reactors. Now, Ponomaryov-Stepnoi became the first deputy director of nuclear energy who dealt with reactor construction.

I, of course, moved around in this circle, choosing my task. I was thinking about what should be the percentage of nuclear energy, and why it should be present in the Soviet energy sector. I was able to organize systematic studies related to the types of stations that should be built, their intended purpose, how they should be used wisely, whether they should only produce electricity or other energy sources [as well], in particular, hydrogen. Hydrogen energy became an area of my close attention.

All these were some unusual questions that complemented nuclear energy. Since Anatoly Pavlovich was himself a reactor man, creator or participant in the creation of many reactors, he needed me not as a reactor scientist, but as someone who, from the outside, could give unusual advice, find unconventional solutions. But all these solutions and advice did not concern the design of the reactors, which I never worked on. They concerned possible areas of use of those components that are in a nuclear reactor.

Because the questions of safety in nuclear energy are the most acute in various spheres of international public opinion, I was interested in comparing the real dangers, the real threats that nuclear energy carries to the threats of other energy systems. This is what I was passionately working on, mainly figuring out the dangers in sources of energy alternative to nuclear energy.

This, broadly, is the range of issues that I worked on professionally. Well, actively aid Anatoly Petrovich in the management of the institute, considering his occupation at the Academy of Sciences—planning the work of the institute, the regime of its work. I tried to establish such things that would bring the institute together, like the Kurchatov General Council, the institute's general seminar, and setting up various publications that would, on order, sit on the desks of researchers so that they could quickly get all the news from their field. I tried to organize opportunities for

comparing different points of view, different approaches to general problems of physics and energy. This I did with quite a lot of enthusiasm.

As for the physics and technology of reactors, it was a forbidden area for me—both because of my own education and because of the taboo imposed by Anatoly Pavlovich Aleksandrov and his subordinates working in this area. They really did not like interference in their professional work by outsiders. I remember how once Lev Petrovich Feoktistov, who had just started working at our institute, attempted to conceptually analyze questions about a more reliable reactor, a more interesting reactor, that would eliminate—this problem was worrying then—the production of such fissile materials that could be removed from the reactor and used in nuclear weapons. But his proposals were met with hostility; as well as the proposals about a new safer reactor from Viktor Vladimirovich Orlov who had come to the institute. They were somehow not considered by the existing reactor community.

Since I didn't have administrative authority over this department but generally understood many specific details of what was going on, and because I was concerned, I began to suggest to the reactor department an engineering, not physical, approach to solving problems. But, naturally, I couldn't considerably change this situation. And Anatoly Petrovich had such a humanly understandable and even likeable trait, namely, reliance on people with whom he has worked for many years. He trusted certain people who worked on, say, naval equipment, station machinery or specialized devices; and really didn't like the appearance of new faces who could somehow bother him or make him doubt the decisions made earlier. This roughly is how things were.

In the scientific sphere, I chose a fascinating field for myself which I have already mentioned—chemical physics related to creating unusual substances, creating systems that would allow obtaining hydrogen in one way or another, linking places where hydrogen is obtained to nuclear energy generation sites. I passionately worked in this area with the involvement of external organisations. It had a very small share in the institute, both from a monetary and human resources perspective. The people there were active and interesting; many proposed a lot of unique solutions that triggered discussions. This created an impression that a lot of attention was being paid to it, but in reality, these were the activities of new people arriving into a new industry. But resources in the form of buildings, staff, funding allocated to this field were certainly not comparable to the money that went to…

[RECORD IS JAMMED]

I was a member of the Science and Technology Council of the Ministry of Medium Machine Building of the USSR, but I was not a member of the reactor unit of this council. So I did not know many details or specific discussions. The Science and Technology Council of the institute frequently held discussions about the conceptual issues in the development of nuclear energy, but very rarely were technical aspects talked about such as the quality of the reactors, the quality of fuel, the problems that were there. These matters were discussed either in reactor units of the Ministry or in the science and technology councils of the respective departments.

Nevertheless, the information I had convinced me that not everything was well in the development of nuclear energy, as it seemed to me. Because it was clear that our devices fundamentally weren't very different from the western ones, say, in their concept; even surpassing them in some aspects. But they were painfully lacking in good control systems and extremely poor in diagnostic systems.

For example, the fact that I learnt that Ramsomson, an American, had analyzed the safety of nuclear power plants. He consistently looked for possible sources of issues that would lead to accidents, systematized them, and made probabilistic evaluations of events, estimates of the likelihood of an event leading to a release of radioactivity. We discovered this from foreign sources. I have not seen a single group in the Soviet Union that raised and considered these issues with any degree of competence.

The most active advocate of nuclear energy safety in our country was Viktor Alekseyevich Sidorenko. But I felt that his approach to the questions of safety was serious. Because he was truly familiar with how stations operated, with the quality of the manufactured equipment, with the problems that sometimes occurred at nuclear stations. However, his effort was mainly directed towards managing these situations: firstly, by organisational means; secondly, by a system for improving the documentation that must be at stations and with the designer; thirdly, he was quite concerned about creating supervisory bodies that would control the situation. All these he called organisational measures.

He and his associates showed great concern about the quality of the equipment that was supplied to the station. Recently, all of us became concerned about the quality of training and readiness of the personnel who design, build and operate nuclear power stations, because the number of facilities had sharply increased, but the quality of the personnel involved in this process had likely decreased and was decreasing before our eyes.

On these matters, I would say, Viktor Aleksandrovich Sidorenko was the leader of the people who were concerned. He didn’t get proper support in our ministry; every document, every step was painfully difficult. This is psychologically understandable because the institution in which we all worked was built on principles of the highest qualifications of people who were executing any operation with the highest responsibility. And, indeed, in the hands of qualified people that did their job well, our devices seemed both reliable and safe to operate. In this circle, concern about additional measures to increase the safety of the nuclear stations seemed a far-fetched issue, because the environment consisted of highly qualified people who were used to being relied on, and were convinced that safety issues are solved solely by skills and by precisely instructing the personnel that led the process.

Military acceptance was also extensive in our industry, so the quality of the equipment was . All this had a reassuring effect. And even scientific work aimed at solving the most important issues of further improvement of stations, both in terms of safety and efficiency did not enjoy support.

More and more resources were spent on creating facilities that were not directly related to nuclear energy. Capacities were created for the production of capacities for metallurgy and extractive metallurgy facilities. A large number of construction resources was spent on creating objects that were not related to the field of the department. Science organisations began to weaken, not strengthen. Slowly, once the most powerful in the country, they began to lose the standard of modern equipment. The staff began to age. Fewer young people joined. New approaches were not welcomed. Gradually, imperceptibly, but it was happening. The habitual rhythm of work persisted and the usual approach to solving problems prevailed.

I witnessed all this, but it was hard for me to intervene in the process purely professionally while general declarations on this subject were received with hostility. Because an attempt by a non-professional to bring some kind of insight into their work could hardly be acceptable.

All the time, new buildings, new stands and new people were required to do the work, because the number of devices was growing. But the growth was not qualitative but quantitative. Moreover, the new specialists reflected the standard of the design organisations in their qualifications. They often practised there. And a good reactor specialist was one who had mastered the design of a particular reactor, who could ably calculate, say, the zone, who knew all the accidents that happen at a station, who could come to any facility and assist in its [ref], quickly figure out what was happening there, and report to the management of the institute or the Ministry.

And so a generation of engineers came up who were very competent, but not critical of the devices themselves, not critical of all the systems that were ensuring their safety; but mainly knew the systems and required an increase in their numbers. This situation was not normal for a science centre.

At the same time, numerous conversations on how to strengthen design organisations with such-and-such specialists and such-and-such approaches were heard at the Institute for a decade and a half, at professional or party levels. But in practice, the design organisations have not strengthened, except for one, but have remained at the same habitual level of carrying out their originally-assigned duties.

So the picture was like this: that everything is safe, and all that is needed is just increasing the number of known stands, increasing the number of people working using a known algorithm, and all would be fine.

The worm of doubt gnawed at me because, in my professional area, I felt that I should always do things differently. You must always do something new, and be very critical to what was done before you. Try to move aside and do something different than what was done before you. Risks could be taken in this work, and I did risk a lot. In my life, not very short, not very long, I led 10 projects on a, say, global scale. And I have to say that five of them had failed. I cost the government around in these failed projects. These projects failed not because they were basically wrong. They were engaging and interesting. But it turned out that the materials needed were not there, or the material scientists didn’t want to, or could not, make them. Then, no organisation would take on the development of an unconventional compressor or an unconventional, say, heat exchanger, again driven by the lack of needed material or experience. As a result, essentially sound projects, when developed, turned out to be overly expensive, cumbersome, and not accepted for execution. This is how five out of ten projects became a failure.

Two of these ten projects, I am afraid, will have the same fate, and for roughly the same reasons. But three projects became very successful, where we found good partners, and where we put in the maximum effort, using the highest levels of the government, using the authority of Anatoly Pavlovich and the Central Committee of the party. As a result, one project alone, of the three successful projects that cost us 17 million roubles, began to generate an annual income of .For four years now, the corresponding industry and technology have been working. To date, it has generated more than half a billion roubles of income for the Government, which more than covers that cost of 25 million roubles for the projects that failed. But the degree of risk in my own projects was quite high. Well, either 30, 50 or 70 per cent of risk is certainly high. But it also had an impressive impact once the work was complete.

In the field of reactors, my attention was drawn to the high-temperature-helium-cooled reactor, molten salt reactor, because I had not seen anything similar. It seemed new to me, although not

entirely new because both of them had already been tried by the Americans. The gas-cooled reactors had been tried out by the Germans. These reactors had shown their considerable superiorities, in terms of efficiency, potential water consumption for cooling the reactor, and the range of uses of such reactors in technological processes. So they seemed novel to me, and, by the way, these reactors also seemed safer than the traditional ones. That is why I provided some sort of patronage for these areas, well, whatever I could provide within the bounds of the Institute's authority. More than that, as part of professional work, I took some part in these areas. But traditional reactor engineering somehow did not interest me much, and it was not assigned to me, and it seemed rather boring.

Of course, I could not imagine at that time the level of danger, the scale of danger that was inherent in those old devices. But there was a nagging sense of anxiety. However, there were such giants, behemoths, experienced people that I thought they would not allow for something unpleasant. And since the literature, the most precise, was western, comparing western devices to our own, this allowed me to conclude in various books and articles that although there are many problems relating to the safety of existing devices, nevertheless, they are still less than the dangers of traditional energy; with its many carcinogenic substances released into the atmosphere, with radioactivity released into the atmosphere from coal seams. And I focussed on this.

I was certainly irritated by the situation that had developed between the Ministry and the science leadership. It was wrong. From talks, from documents, I knew that the original position was this. Our Institute was not part of the Ministry of Medium Machine Building. It stood beside it, as a separate independent organisation, and had the right to dictate its scientific requirements and positions. And the Ministry, after evaluating the scientific proposals, was technically obliged to execute them precisely. This was the partnership. Scientific proposals not being limited by the influence of those in power, and full opportunity for the execution of such proposals that the Ministry liked from an engineering point of view, was [the] correct [way of operating].

But then, history came to such a state where science became subordinate to the Ministry. The ministerial cadres grew up and acquired their own extensive engineering experience. It seemed to them that they already understood everything in the scientific arena. And so, the scientific spirit and the scientific atmosphere in reactor engineering gradually began to submit to the engineering will, as it were, to the ministerial will. I saw this; it bothered me. And it complicated my relationship with the Ministry when I tried to, not very carefully, speak out on this issue. And I could not win in these matters because, to the reactor people from the Ministry, I was a chemist, and this allowed them to not listen to my opinions carefully and to treat my suggestions as sort of fantasies. This was the general environment in which all this work was happening.

As for the RBMK reactor, you know, in reactor circles, it was considered a bad reactor. Viktor Alekseyevich Sidorenko had repeatedly criticised it. But this reactor was not considered bad because of safety reasons. From a safety point of view, it even stood out as being better, as I understood from the discussions. It was considered bad because of economic reasons. First, for higher fuel consumption; for higher capital costs; and for a non-industrial basis of its construction. Also worrying was the fact that it was an isolated Soviet line of development. Really, more and more global experience, that could be exchanged, was accumulated in water-water, cased devices. Operating experience, technical solutions that had been used, software, all these could be exchanged and adapted. But for RBMK reactors, all the experience was domestic. And if we took the

accumulated statistics, then the statistics on the operation of RBMK reactors were minimal compared to the VVER. devices. This was just as worrying.

I, as a chemist, was worried about the huge potential for chemical reactions in these devices. There is a lot of graphite, a lot of zirconium and water. And under some anomalous conditions… In normal conditions, of course, the graphite comes into contact only with inert material which was ensured by appropriate technical solutions. A temperature at which a vapour-zirconium reaction could begin, accompanied by the generation of hydrogen was, in principle, unacceptable, be it routine work or technical conditions. Nevertheless, the potential reserve of chemical energy in a device of this type was maximal relative to, say, another comparable device. This too was a point of concern.

When I looked at this device, I was confused by, for example, an unusual and, in my opinion, insufficient construction of safety systems, that would work in extreme situations. Because the safety of the device in case of some abnormal behaviour… For example, a positive reactivity coefficient in this device, should it start to develop, become noticeable, then the operator, and only the operator, could lower the emergency rods. Or they could be lowered automatically after one of the sensors sent a command; there were several such safety systems. Or manually, using the special AZ-5 button to reset the emergency rods. This device did not have any mechanical rods (mechanical, well, it could work well or it could work badly) or other safety systems that would be independent of the operator, and would work solely based on the state of the zone. This created an uncomfortable situation. But still, some practical experience had already been accumulated. Specialists exhibited confidence in these aspects.

The speed of introducing safety systems was, as it seemed, insufficient. I heard often that specialists, Kramerov Aleksander Yakovlevich in particular, while discussing these problems with Anatoly Petrovich Aleksandrov, made proposals to the [reactor] designer to change the accident protection system (APS), to improve the APS of this device, and they were not rejected. But they [the safety systems] were developed very slowly. Moreover, by that time, the relationship between the science director and the chief designer became, well, quite tense.

For all new projects and new ideas, this design organisation fully recognized the authority of the Institute of Nuclear Energy, and readily consulted with it and maintained contact. But with regards to this particular device [RBMK], they considered themselves absolute creators and owners. They did not violate the formal order in which the scientific leadership was under the Institute of Nuclear Energy. In fact, this leadership was, to a large extent, nominal in nature. It was used for such cases when, say, key decisions were taken like whether to make the RBMK 1500, or whether to introduce a heat exchange intensifier to this reactor. For example, when there was a need to propose that the share of RBMK devices in nuclear energy be increased, then Anatoly Petrovich Aleksandrov's support was required on this issue. These questions were discussed with the director. But in questions of specific technical policy or improvements to this device, the designer was unwilling to accept the Institutes's point of view, not considering it to be a sufficiently-developed partner for it to be useful to the designer in his work.

In this context, I want to state an opinion, of which I am fully convinced, but which, unfortunately, is not shared by my colleagues, and leads to friction between us, sometimes quite dramatically. The thing is that, as far as I know, and it is logical, there is no concept of a science supervisor or chief

designer in the developed industries in the West and the Soviet Union. I understand this myself; scientific stewardship is a problem.

For example, a scientific supervisor for aviation. Although it likely doesn't exist, I could imagine it. It would be an organisation that would be responsible for the developmental strategy of aviation. How many small aircraft, how many large ones; whether to prioritise comfort when boarding or deboarding passengers, or the speed of travel between two points; whether to give preference to [the development of] hypersonic aircraft or supersonic ones; is ensuring comfortable and reliable operation of ground crew more important for safety, or the work of personnel onboard the aircraft; what should be the percentage of various types of aircraft. This kind of scientific management of aviation seems right to me.

But when it comes to the design of a [particular] aircraft, it must have a single owner. He must be the designer, the engineer and the science supervisor. All the power and all the responsibility must be in the same hands. I see this as an obvious fact.

At the time of the birth of nuclear energy, everything was sensible, because it was a completely new field of science - nuclear physics, neutron physics. The concept of science leadership came down to a system where the basic principles of constructing a device were given to the designer, and the science supervisor was responsible for those principles to be physically correct and safe. But it was the designer who implemented these principles, in constant, daily consultation with the physicists on whether any physical laws of the device were being violated.

All this was justified at the dawn of the nuclear industry. But as the design organisations have grown, when they have set up their own physics departments and calculation departments, then this system of dual ownership of the same device has come about—there is a science supervisor and a designer. In fact, there is triple ownership, because there is also a head office, or some deputy minister, who has the last word on a particular technical decision. Numerous councils, interdepartmental or departmental, created an overall atmosphere of joint responsibility for the quality of the device. This situation continues today. It, in my opinion, is wrong. I am still convinced that the science supervisor, the organisation of science supervisor which scrutinises projects and selects the best one, thereby defining the development strategy of nuclear energy... This is the function of the science supervisor, not creating a particular device with given properties. All this confusion has led to a great deal of irresponsibility which was exposed by the Chernobyl experience.

One way or another, the system of multiple owners... The system of a singular person being personally responsible for the quality of the device—with all the facilities it was installed in—was absent. And this caused appropriate alarm among professionals, in technical and engineering sense. Obviously, it was difficult for me to judge the merits and demerits of this or that device. However, the thing that I was able to achieve was to create an expert group that would perform an expert comparison between different types of devices, in terms of their economy, universality and safety.

The first two such consecutive works by experts were interesting. The idea of creating such an expert group and doing this work was mine. I helped organise this activity, and the actual work was done by Aleksander Sergeyevich Kachanov's laboratory created specifically for this purpose. He, in my opinion, organised the work perfectly. Because his laboratory was a kind of cell that posed questions and formulated them physically; while the answers to these questions were given by specialists, not only from the various departments of the Institute but also from different institutes.

As a result, a basis emerged that could be discussed widely, critiqued and supplemented. But this work was unfortunately suspended at the very beginning, initially because of a serious illness of Aleksander Sergeyevich Kachanov and an inability to find an equivalent replacement, and then because of the subsequent Chernobyl events.

The 26th of April 1986 caught the Institute of Nuclear Energy in a rather odd position. With the approval of the director of the Institute, with his full support, the first deputy was working on organising system-wide research on the structure of nuclear energy, an activity that was of little interest to the Ministry and was happening solely because of the support from Anatoly Petrovich Aleksandrov. The Institute did acquire a taste of it. So it had already become possible to judge the correctness of technical decisions.

At the same time, I managed to set up a laboratory for safety measures that evaluated the various dangers of nuclear energy compared to other types of energy. For the first time, there were specialists that took …

[TAPE ERASED]

… soon it was necessary to literally fight for the correct implementation of every technological mode. This is when Aleksander Petrovich and Vyacheslav Pavlovich Volkov, director of the Kola and then the Zaporozhye nuclear power stations, recently told me about an episode, where a group of his comrades visited the Kola station, and witnessed, in his opinion, a complete disorder in the organisation of the technical process. What examples did he give? Say, a duty officer starts their shift. He would fill out all the measurement journals beforehand, all the parameters, even before the end of the shift. And then stared at the ceiling til the end of his shift, doing practically nothing. Maybe only the chief engineer of reactor control sometimes left his chair to carry out some operations. But apart from that, it was still and silent. No careful monitoring of the instrument, no attention to the condition of the equipment between planned preventive maintenance.

So his comrade, having arrived to get familiar with the work of this [Chernobyl] station, reported that everything was wrong there. The director of the station, Briukhanov said when Volkov called him, ‘What are you worried about? Yes, a nuclear reactor is like a samovar; much simpler than a heat station. And we have experienced personnel. Nothing will ever happen.’ Well, he [Volkov] was very wary. As he told me later, he called Veretennikov in the Ministry of Energetics about this, then Shasharin, got as far as Neporozhniy, and then reported it to comrade Maryin at the Central Party Committee. But he was told, ‘Don’t stick your nose in the wrong place.’ Only Neporozhniy said, ‘I’ll go take a look”. He went, had a look, and said that everything was in order and that the information was wrong. And this was not long before the Chernobyl disaster.

I think that we should look at the work in other industries [as well]. I had to visit various chemical facilities. I was particularly horrified by a phosphorous processing plant in the Chemkent region. This phosphorous plant was something frightful, both from the perspective of the quality of technologic and the saturation with diagnostic devices. Terrible working conditions. Many supervisors that should have been on the staff were just absent. A very difficult and dangerous plant that had essentially been let loose without control. It was scary to see such a situation.

That’s why I understood the words of our Chairman of the Council of Ministers in a larger context, that it is not a feature of the development of nuclear energy that has come to this state, but a feature of the development of the national economy that has led to this. It didn’t take long for a confirmation of the correctness of my understanding of these words. In a few months, the Nahimov

collision happened, such a severe disaster with the same carelessness and irresponsibility; then a methane explosion at a coal mine in Ukraine; a train collision in Ukraine—all these within a short time. All of this reflected a certain general serious technological inefficiency and indiscipline in almost all crucial areas of our work.

And now, the situation is indeed like in the Lev Nikolayevich Tolstoy's story—"There are no guilty in the world." When one looks at the chain of events, why someone acted in this way and another in that way and so on, it is impossible to point to a single culprit, an initiator of all the unpleasant events that led to the crime. Because it is a chain that links to itself. The operators made mistakes because they had to complete the experiment which they considered a matter of honour. This is what led them, and directed their actions. The plan for the experiment was drawn up very poorly, very imprecisely, and not authorised by the specialists by whom it should have been authorised. In my safe is a record of telephone conversations between the operators on the eve of the accident. Reading these records makes your hair stand on ends. One operator calls another and asks, ", here in the program, it's written what needs to be done, but then a lot of it is crossed out. What should I do?" And the second one answers, "You do what is crossed out." Can you imagine? This is the level of document preparation for a facility as serious as a nuclear station. When someone crossed out something, the operator could interpret it as right or wrong and could perform arbitrary actions.

But again, it would be wrong to place all the blame on the operator, because someone made the plan, someone scribbled on it, someone signed it, and someone did not coordinate it. And the very fact that the station could independently perform any actions not authorised by the experts is already a defect in the relationship of the experts with this station. The fact that representatives of Government Nuclear Energetics Supervision (GNES) were present at the station, but were unaware of the ongoing experiment, were unaware of this programme—this is not just a fact of the station's biography, but a fact of the biography of the GNES employees, and the existence of this system itself. These are all the thoughts that come to mind in connection with the Chernobyl accident.

But let's get back to the Chernobyl events, from which I have deviated so far. As far as I remember, I stopped the story at how I was struck by the precise work of our chekist [the KGB], who without any fuss, with very few people, did a lot of work to establish communications and bring order in the zone of the accident. Similar [good] words can be said to theMinistry of Internal Affairs of Soviet Union, and Ukraine as well, because the evacuation process, the rapid cordoning off of the zone, and quick establishment of regime and order, as much as possible—they did that very well. Although it must be said, there were separate cases of looting or intrusions into the zone with the aim of stealing. But the number of such attempts was small, and they were quickly suppressed.

The air force, the helicopter groups, worked very precisely. This was simply an example of superior organisation and ignoring any danger, working very carefully and accurately. All the crews always tried to do the assignments, no matter how difficult or complex the task was. The first days were especially difficult. An order was issued to prepare the sandbags. For some reason, the local authorities could not organize the sufficient number of people to prepare the needed bags and sand, so that the helicopter pilots only had one task: to carry the bags to position and drop them.

END OF SIDE B