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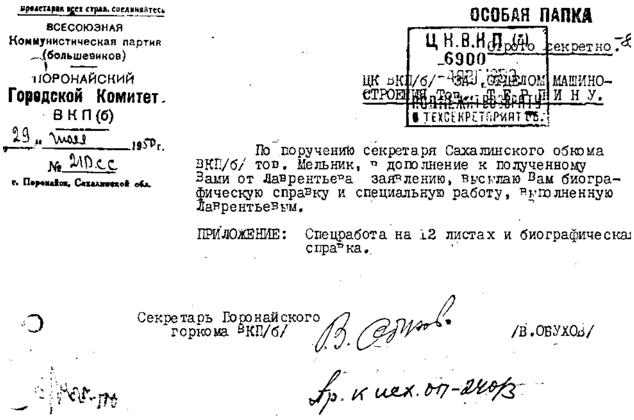
Lavrent'ev's proposal forwarded to the CPSU Central Committee on July 29, 1950


Пролетарии всех стран, соединяйтесь
ВСЕСОЮЗНАЯ
Коммунистическая партия
(большевиков)
ПОРОНАЙСКИЙ
Городской Комитет
ВКП(б)
29 июля 1950 г.
№ 210сс
г. Поронайск, Сахалинской обл.

ОСОБАЯ ПАПКА
Строго секретно
ЦК ВКП/б/ – ЗАВ. ОТДЕЛОМ МАШИНОСТРОЕНИЯ Тов. – ТЕРПИНУ.

По поручению секретаря Сахалинского обкома ВКП/б/ тов. Мельник, в дополнение к полученному Вами от Лаврентьева заявлению, высылаю Вам биографическую справку и специальную работу, выполненную Лаврентьевым.

ПРИЛОЖЕНИЕ: Спецработа на 12 листах и биографическая справка.

Секретарь Поронайского горкома ВКП/б/ /В.ОБУХОВ/

Facsimile of the covering letter for Lavrent'ev's paper.

The forwarded paper involves three separate proposals:

(1) Methods of utilizing energy of lithium – hydrogen reactions and its transformation into electric energy.

(2) Methods of transformation of the energy of uranium and transuranium nuclear reactions directly into electric energy.

(3) Possible applications of the energy of a ($Li^6_3 - H^2_1 - 2\alpha$) reaction for military purposes (the lithium – hydrogen bomb).

The contents of the paper are divided into four parts:

I. Basic ideas.

II. Experimental setup for transforming the energy released in lithium – hydrogen reactions into electric energy.

III. Experimental setup for transforming the energy released in uranium and transuranium nuclear reactions into electric energy.

IV. Lithium – hydrogen bomb (design).

Unfortunately, I was unable to complete Parts II and III of the paper and so send here only brief expositions. Part I was also written in a rather superficial way. I consider my personal participation in any discussion of the project to be advisable.

Lavrent'ev

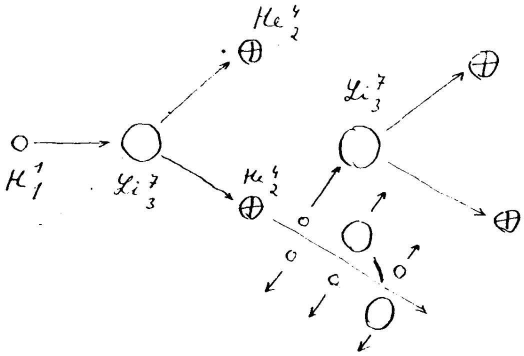
Contents

Part I

$$Li^6_3 + H^2_1 = He^4_2 + He^4_2 + 500 \text{ mln Kcal}$$
$$Li^7_3 + H^1_1 = He^4_2 + He^4_2 + 400 \text{ mln Kcal}$$

1. Among all the approaches to using the energy of proton nuclear reactions of the type shown above, the only practically useable one is the method of free collisions between nuclei. Essentially the method consists in the following:

Lithium and hydrogen nuclei move freely at velocities on the order of $10^6 - 10^7$ m/s in a certain sufficiently large volume. When a proton collides with a lithium nucleus, a complex unstable nucleus is formed which decays into two α-particles with total energy on the order of 17 MeV. The α-particles moving in opposite directions transfer their energies via collisions to neighboring nuclei which again interact with each other. The following chain reaction occurs:



This reaction can occur if the amounts of reactants are sufficiently large, which in its turn depends on the volume of the setup and its strength. The reaction will take place if one to two nuclear transformations happen per every 100 nuclei moving from the center of the setup towards its surface.

2. In order to impart sufficient initial velocity to lithium and hydrogen nuclei, we can make use of the chain reaction between plutonium nuclei. The simplest way to achieve it is to explode an atomic bomb in a medium consisting of 87.5 percent lithium and 12.5 percent hydrogen. Lithium hydride, being a solid component, is very convenient in this respect. Fast particles formed in the explosion of the atomic bomb in large numbers will transfer their energy to the lithium and hydrogen nuclei, which will start to react among themselves. The nuclear reaction will be explosive, the explosion being more powerful than that of the atomic bomb.

I must remark that the first layers directly adjacent to the atomic bomb must consist of the isotopes Li^6_3 and H^2_1. This would require considerably more time and expense but would guarantee success, because, firstly, the nuclear reaction between the nuclei Li^6_3 and H^2_1 has roughly a 30-fold yield (this is based on British sources); secondly, it consumes more energy, and thirdly, Li^6_3 nuclei will react with neutrons (note, however, that this reaction gives only one fourths of the energy produced by ($Li^6_3 - \alpha - 2\alpha$) reaction)[1].

3. Proton nuclear reactions seem to be realizable only on a large scale (in units on the order of hundreds of thousands and millions kW of power). Therefore, the power extraction is one of the most difficult problems. It would of cause be possible to try and use old well-worn thermal methods. For instance, the walls of setup could be made of pipes so that hydrogen could be blown into the pipes under pressure; having absorbed fast particles and thus heated up, hydrogen would escape through another set of pipes, after which it would drive gas turbines. However, this

[1] This is what we see in the document. Judging by meaning, one should read it as $Li^6 + H^2 \to 2He^4$

approach to power extraction will demand restructuring the entire energy grid, developing new superpower turbines, compressors, generators and, as a result, leading to huge financial outlays.

4. I suggest a different way of power extraction: the method of electrostatic absorption of the energy of fast particles in a decelerating electric field. This method will allow: first, to extract most of the nuclear energy (around 80 – 90 percent) in the form of a high-voltage dc electric current, and second, to reduce the dimensions of the setup.

The method consists essentially in that charged particles passing through the decelerating electric field transfer their energy to this field. If we surround a certain volume in which proton nuclear processes take place by two bounding envelopes (the inner one must be a grid) and apply high dc voltage on the order of 0.5 – 1 MV (positive potential on the outside surface), then positively charged nuclei flying through the grid will find themselves in the decelerating electric field and will either be thrown back and again take part in nuclear processes (if their energy is lower than the energy of the retarding field) or, if their energy is greater than that of the retarding field, will reach the outer envelope and transfer their charge to the surface.

Since the reaction between lithium and hydrogen nuclei inside the grid cavity constantly releases energy, the mean velocity will remain constant and the reaction will be sustained despite the losses in the grid and also despite the transfer of part of the energy to the decelerating field.

5. The reaction will proceed if the energy absorbed by the grid is smaller than the energy released as a result of the nuclear reaction. It is always possible to choose the size of the setup in such a way that the energy absorbed by the grid remains smaller then the total released energy (the volume is proportional to dimensions cubed, while the area, to dimensions squared). Hence, the problem of the feasibility of a given nuclear reaction can be regarded as solved. The question of choosing the size of the setup is only left open. I think that dimensions on this scale do not go beyond the capabilities of the building equipment: first, optimized design could to some extent reduce the loss factor on the grid, and second, we can increase nuclear flux density (also to a certain extent) if we increase the strength of the design (we need to take into account the strength of both the outer shell and the grid), and third, the first pilot setup will operate using the isotopes Li_3^6 and H_1^2 — that is, will work in the most favorable conditions.

Part III

The method of electrostatic absorption of energy of fast charged particles in a decelerating electric field can be successfully applied to the transformation of nuclear energy of uranium and transuranium reactions directly into electric energy.

In principle, the method remains identical to that suggested for lithium – hydrogen nuclear reactions. Since the splitting of plutonium nuclei occurs as a result of neutron collisions, the energy of the decelerating field can be chosen in a relatively wide range, which at the same time controls the nuclear flux density.

At the onset of the process, plutonium (in ionized form) is injected into the setup. Once the reaction starts, it is sustained by adding uranium-238 (natural) which transforms into plutonium by colliding with neutrons and takes part in the reaction. To extract energy, it is also necessary to add ions of an inert substance with low nuclear charge (H_1^2, H_1^1, He_4^2).

It is interesting to point out that in all likelihood collisions of neutron-reach nuclear fragments with other nuclei may result in a liberation of neutrons. If that is indeed so, the possibilities of my method increase even more.

This method does not require additional decontamination from reaction products because fragments of nuclear fission are the first to be ejected. The energy is partially transformed to thermal energy, so the housing and the grid must be cooled.

The geometry of the housing must be cylindrical, with a rounded top. The grid is formed of individual pipes joined above and below by connecting tubular rings (squirrel wheels). The tubular rings are mounted on insulators. The insulators contain channels for passing a coolant; the insulator – ring joints are hermetically sealed.

(I will describe details in a conversation or in a separate paper.)

Lavrent'ev's draft comments to Parts I – IV

I. On the possibility of the lithium – hydrogen nuclear reactions.

Two conditions must be satisfied for the reactions of the type ($Li_3^6 - H_1^2 - 2\alpha$) and ($Li_3^7 - H_1^1 - 2\alpha$) to proceed successfully.

1) Nuclei must move at velocities that ensure running of the nuclear reactions in their reciprocal collisions.

2) The total number of collisions between nuclei must be sufficiently high.

The necessary initial velocities of nuclei are achieved by applying high-voltage electric field and are then sustained by the nuclear reaction itself. Notice that a harmful electric field directed against the main field forms between the grid and the nuclei found at the moment in the grid cavity. This field reduces the velocity of nuclei; therefore, the effect of the space-charge field on the velocities of nuclei must also be taken into account when choosing the voltage of an accelerating electric field between the grid and the housing.

The factors affecting the second condition are the density of the nuclear flux and its linear dimensions.

The nuclear flux density depends on the velocity of nuclei and the mechanical strength of the setup (the strengths of both the housing and the grid are taken into account). The density in question can be greatly increased by applying the nuclear flux focusing in space and in time. It is not difficult to prove that under ideal conditions the nuclear flux density will increase from the surface of the setup towards its center as a square of the linear dimensions of the volume taken.

The nuclear flux focusing in space is achieved by a rational design of the housing and of the grid. The focusing in time may be achieved by applying high-frequency electric field.

II. Experimental setup

1. The design of an experimental setup meant to utilize the nuclear energy of proton reactions will have to solve numerous large and smaller problems that would require participation of highly skilled specialists from various fields of science and technology; hence, I cannot pretend to claim that this part of my work is fundamental or final. Many aspects will definitely need elaboration or even complete reworking. Basically, I wish to outline the plan of further work and also to develop my ideas regarding the actual design of the system.

The setup consists of the skeleton, grid, cooling system, vacuum unit, protection devices, start-up system, focusing devices, decontamination equipment and systems for adding new products to the reaction (high-frequency generator) and other details of lesser importance.

2. Grid

The grid must satisfy the following requirements:

(a) low absorption coefficient for fast particles;

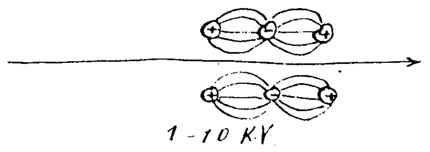
(b) mechanical strength and roundedness of the construc tion;

(c) reliable electric insulation from the housing;

(d) possibility of high-intensity cooling;

(e) suppressed thermionic emission.

The following approaches to lowering the grid absorption coefficient are possible: first, the useful area of grid 'windows' can be increased to a certain degree, and second, nuclei can be focused and sent right into the +0.5 MV grid windows (electrostatic lens).



The grid is made of interconnecting pipes. The pipes are cooled by the flux of an electrically nonconducting liquid. The grid is mounted inside the housing on glass or ceramic supports that at the same time serve to supply and remove the coolant. The thermionic emission can be suppressed by a special coating.

3. The size of the setup must be such that:

(a) the distance from the center of the setup towards the grid must be several times greater than the free range of nuclei;

(b) there is no charge leaking from the grid in points of field overvoltage on some nodes of the grid.

4. The shape of the setup skeleton is spherical. Only a part of nuclear energy is deposited on the skeleton in the form of heat, so that air cooling of the outer surface is possible. If the system is to be installed underground, water cooling of the outer shell must be included in the project.

Vacuum pumps must ensure sufficient vacuum inside the setup in the course of its operation and also the removal of reaction products. High vacuum is not mandatory. Oil pumps can be used.

5. The setup start-up is achieved by a massive injection to it of lithium and hydrogen nuclei with energies in the range from 100 to 500 thousand electron-volts.

To start the system, auxiliary high-voltage source of sufficient power is required (transformer with gas discharge rectifiers).

Before the start-up, air is removed from the setup, an appropriate dc voltage is applied to the grid and the housing (positive polarity on the housing). Hydrogen with atomized lithium is injected into the space between the housing and the grid, and the atoms are ionized in the high-voltage field. Electrons are absorbed by the positively charged housing, while ions fly towards the grid and, passing through the holes, penetrate the grid cavity.

6. To maintain the constant composition of the reactants, it is necessary to periodically inject new amounts of matter into the setup. These substances must also be injected as ions. Sufficiently high voltage (on the order of hundreds or thousands of volts) is used to ionize atoms. The positive electrode must be connected to the grid.

Quantitatively, the reactants are injected in the proportion of 10 – 15 g of lithium-6 per hour per 1 million kW of power. Deuterium is injected in amounts 50 to 100 times larger (part of deuterium ions is ejected before they have a chance to react).

7. To decontaminate the setup from the reaction products, another grid is installed at a small distance from the housing. The nuclei that penetrate through the decelerating field go through this grid and get into the zone of zero potential. Moving now by inertia, they reach the housing, transfer their charge to it and become neutral atoms which are then removed by vacuum pumps. It is advisable that electrodes insulated from the housing and being under a small negative voltage (relative to the housing) be inserted into the pipes of vacuum pumps. Although this system of purification entails a certain loss in useful power, it provides for better decontamination from reaction products.

8. Maximum power is determined by:

(a) setup dimensions;

(b) nuclear flux density;

(c) the loss factor of the grid;

(d) the choice of specific reactants.

Power output can be controlled by changing the relative composition of the reactants. As this variation requires a certain time interval, power cannot be changed immediately and, therefore, the load must be kept constant during the entire time of operation of the setup. If overloaded, the voltage falls off and the setup deviates from the normal mode of operation. If underloaded, the voltage grows uncontrollably threatening insulator breakdown. The load is controlled by automatically connecting or disconnecting an additional resistor. It is desirable for this resistor to also have a useful function (recharging of batteries, water decomposition, etc.).

9. The protective measures consist in connecting or disconnecting additional load resistances. The signals for using them are the changes in voltage across the setup.

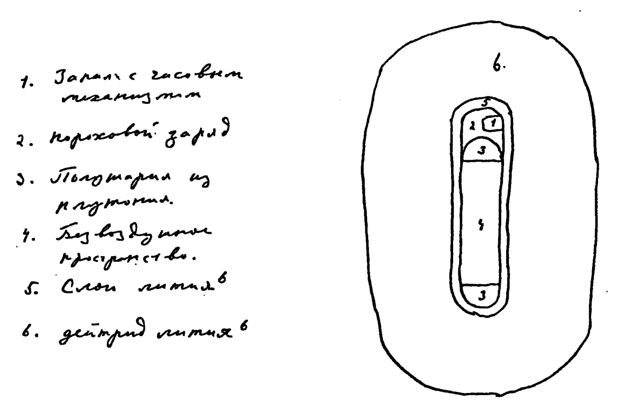
10. Soviet scientists — experts in energy generation — were already working in this field. As far as I can conclude from journal publications, the work was successful. I have no knowledge of the results achieved.

IV. Lithium – hydrogen bomb (layout)

I have already described the essential design of a lithium – hydrogen bomb in Part I.

The design of the lithium – hydrogen bomb is relatively simple. The bomb consists of a detonator (a conventional atomic bomb) surrounded by a layer of lithium-6 deuteride, i.e. a compound of Li_3^6 and H_1^2 isotopes. The amount of this 'explosive' is determined by the desired power of the bomb.

The production of this bomb involves considerable expenditure of means on isotope separation. Both isotopes can be separated from natural compounds by electrolyzing them for a long time. (The abundance of H_1^2 in the natural hydrogen is 0.014 percent, that of Li_3^6 in the natural lithium — 7.93 percent).



1. Detonator with a timer. 2. Powder charge. 3. Plutonium hemispheres. 4.Vacuum. 5. Lithium-6 layer. 6. Lithium-6 deuteride.

To finalize the design of experimental setups, I suggest to create a scientific team of the following composition: 2 – 3 specialists in nuclear and molecular physics; 1 – 2 experts in electrical engineering and radio engineering; 1 – 2 experts in thermodynamics; several construction engineers (metal and reinforced concrete constructions); several power production engineers (among them, experts in high-voltage dc transmission lines), and various other technical experts.

The team must be given command of:

— a research institute;

— a cyclotron to 1 – 2 MeV;

— a power supply facility for generating voltages from 100 to 500 kV;

— a plant and equipment for (electrolytically) separating Li_3^6 and H_1^2 isotopes.

Lavrent'ev

APRF, Fond 93, Delo 30/51, Listy 73-83. Autograph.