EXPERIMENTAL RESEARCH INTO LOW ENERGY NUCLEAR REACTION IN CONDENSED MATTER WITH EXCESS HEAT AND IMPURITY NUCLIDES PRODACTION

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Abstract
The experimental data of investigation into low energy nuclear reactions (LERN) in condensed media are presented. The nuclear reactions products were researched in the solid cathode medium of a glow discharge. Hypothetically the nuclear reactions were initiated when bombarding the cathode surface by plasma ions with the energy of 1.0-2.0 keV. The results on recording excess heat power under the experiments with a high-current glow discharge in D_2, , when using preliminary deuterium-charged Pd and Ti cathode samples are given. The excess heat power up to 10 –15 W and efficiency up to 150 % was recorded under the experiments for Pd cathode samples in D_2 discharge. Forming the impurity nuclides with the efficiency up to 10^{13} atoms/s was recorded. Large deviation of the registered isotopes relation from the natural relation of these elements isotopes was observed. The soft X-ray radiation from the solid-state cathode medium with the intensity up to 0.01J/(s·2□) was recorded under the experiments with the discharge in D_2,. The X-ray radiation was observed as bursts (up to 10^6 photons in a burst and up to 10^5 bursts a second) during the discharge burning and within 100 ms after turning off the discharge current. The possible mechanism of producing the excess heat power and products of nuclear transmutation reactions in the solid medium with the exited energy levels was considered.

I. INTRODUCTION

The experimental researches of an opportunity of carrying out low energy nuclear reactions (LENR) in condensed media have been carried out recently. By LENR we mean nuclear reactions initiated by a low energy action (from unites up to a thousand of eV) in the condensed media. Under such a low energy action the non-equilibrium energy states with a temperature up to 3keV and life time up to some tens of ms are possible to be formed in the condensed medium. Occurrence of such states was found during the experiments when registering X-rays with energy up to 3keV.Hypothetically, X-ray emission and other accompanying effects are displaying a new fundamental physical phenomenon unknown before:
The metastab le long-living (up to tens of ms) states with the excitation energy of 1.5 - 3.0 keV and more are formed in the crystal solid lattice within the solid when

bombarding its surface by plasma ions of an electrical discharge . Therefore, L, M excited energy states with the occupation density $n_{v\text{-}d}$ (cm^{-3}) and characteristic temperature $T_{L,M} \approx 1.5$ - 3.0 keV and more (20, 000, 000 ˚K) are formed in the solid after each pass of the current glow discharge pulse. These power condition exist for the characteristic time $\tau_{L,M}$ (up to 100 ms and more). Realization of nuclear reactions of transmutation with evolving heat power and accumulation of impurity elements within the cathode material is possible in such medium. The probability of such reactions proceeding is defined by the characteristic temperature, excited energy levels density and life time of excited levels. These nuclear reactions (LENR) can be called non-equilibrium nuclear reactions.

The experimental measurements of the excess heat power yield, storing impurities of the elements isotopes in the cathode material, recording heavy particles emission and soft X-rays at large densities of the discharge current were carried out with the device of the high-current glow discharge for a long time. As applied to developing a long operating reactor for the heat power production, the research of the modes with a small density of the discharge current for finding out a possible mechanism of initiating non-equilibrium nuclear transmutation reactions in the solid medium of the cathode sample was carried out.

II MEASUREMENT OF EXCESS HEAT BY A FLOW CALORIMETER

The measurements were carried out using the glow discharge device consisting of a water-cooled vacuum chamber, cathode and anode assemblies. The cathode design allowed placing the cathode samples made of various materials on the cooled surface. Three units of the device: the cathode, anode and chamber had independent channels of water cooling. Each cooling channel included two thermal resistors differently turned on at the input and output and a volumetric counter of the cooling water consumption. The device was placed into a thermal insulating package (Fig.1) and was a flow calorimeter. Non-deuterium-charged Pd cathode samples in Xe and Kr discharges were used in the tests. In contrast to the experiments carried out before, the mode of “plasma anode” was used. The anode was set out at the chamber wall (Fig.1) and was put into the plasma area being above the cathode. The pulse- periodic electrical power supply was used. The electrical parameters: discharge current and voltage were recorded using a two-channel computer digital oscillograph. The electrical power was determined according to the expression

$$P_{el} = 1/T \int U(t)\, I(t)\, dt.$$

When being the source of the excess heat release inside the chamber P_{EH}, its value could be determined by

$$P_{EH} = (P_{HC} + P_{HA} + P_{HCh}) - P_{el} \pm \Delta P_{error}$$

where P_{el} – input electrical power of the glow discharge, P_{HC}, P_{HA}, P_{HCh} – output heat power by the cooling water of the cathode, anode and chamber respectively, ΔP_{error} –

complete absolute error of the power measurement for given measuring system, T –period of following the pulses of the glow discharge current. The measurements system allowed to record the electrical power input into the discharge and heat capacity output by the cooling water with accuracy of 0.6 W at the absolute value of the electrical power up to 120 W (Relative error ±0.5%,).

Two typical operating modes of the device were used in the experiments. The discharge current of a high density (more than 20 mA/cm^2) was used in the first experiments set. Under these modes deuterium loading into Pd cathode samples did not take place. The absolute excess power had a large value (up to 20 W) but total efficiency coefficient was less than 130%. In the other set of the experiments the current density did not exceed 100 mA/cm^2. Under such values of the discharge current in D_2 , a continuous loading of D_2 into Pd ran up to saturation. The experiments were carried out with Pd cathode samples D_2 discharge, with the preliminary deuterium-charged Pd cathode samples in Xe and Kr discharges. The amount of the loaded D_2 was determined by reducing the pressure in the chamber. D_2 was periodically supplied into the chamber for maintaining the required pressure. The amount of the loaded deuterium into palladium was determined by the volume of the gas absorbed from the discharge chamber. When achieving the load, the value of the relation D/Pd was close to 1.

The heat measurements were carried out for Pd cathode samples in the discharge when changing the following parameters: discharge current density, voltage, duration of current pulses and time period between the current pulses of the power supply. The absolute value of the excess heat power and thermal efficiency grew with increasing the power input into the discharge. The maximal values of the excess heat power and thermal efficiency were recorded under the following conditions in the experiments: in the modes when loading D into Pd took place, or when D left Pd; in the modes, when the time period between the current pulses was much greater than the duration of the discharge current pulses.

This result specified that the excess heat power went on releasing in the cathode sample after turning off the current (in the time period between the current pulses). The maximal values of the excess heat power were recorded at the discharge burning voltage of 1000 - 1400 V.

The enough large values of the excess heat power and thermal efficiency were recorded for previously deuterium-charged cathode samples in Xe and Kr discharges (Fig.2). Two typical groups of the results can be noted: relatively large values of the excess heat power and efficiency coefficient (curve 1) and the group the results with lower values of the excess heat power efficiency coefficient (curve 2). The large values of the excess heat power and efficiency coefficient were observed under the modes when a partial loading of deuterium into Pd cathode samples took place or when deuterium left Pd cathode samples. The excess heat power was not produced when using the cathode samples made of pure Pd (not deuterium-charged) in Xe and Kr discharges (Fig.4). Thus, it was experimentally shown, that the excess heat power production was defined by two

processes. 1 - deuterium should be loaded into the medium of the crystal solid lattice. 2- crystal lattice should obtain initial excitation, high-energy long-living exited levels should be created in the solid. These exited conditions could be created by an additional source (for example, by a flow of inert gas ions)

The three-channel system of separate recording of the output heat power (anode, cathode, and chamber) allowed defining the structure of the excess heat power in the glow discharge. The graph (Fig.5, 6) shows, that the large efficiency values were recorded in the experiments with the large relative heat release on the cathode. These results show that the excess heat power was released mainly on the cathode.

The gamma-radiation registration

The gamma-radiation registration was carried out using Ge – Li detectors and multichannel spectrum analyzer. The detector with the glow discharge plant was arranged into the camera made of lead with thickness of 10 mm.

Gamma – radiation in the range of 0.1 –3.0 MeV is observed during burning the discharge and after turning off the discharge current during up to 8 days. During the long intervals between experiments (up to some months) the multiple registration of the background spectra also was carried out. Every time the background was recording 10 – 14 days later after last turning on discharge. The registration time for one spectrum was 1- 65 hours. The spectra were led to energy scale by the calibration on the standard sources. Further within the selected energy interval on all the channels of analyzer the total sum of events was defined and was divided by time of spectrum registration. The value of gamma – radiation was defined taking into account the geometrical and physical detector efficiency and the registered value of background. The value of gamma background fluctuation did not exceed 10% during this time (5 months). Using the cathodes made of the different materials the value of inductive gamma- radiation after turning off the discharge current increases with increasing dose of radiation by ions (D2, H2, Ar, Xe) of plasma forming gas for the cathode sample (Fig.7). The groups of radioactive nuclides with half – life period of from 1 to 6-7 days are observed in the spectra registered from one PD cathode sample during 8 days after turning off the discharge. The spectra of inductive gamma – activity include the areas of exceeding the continuous spectrum (continuum) and the lines imposed on them. In this case the value of exceeding the area of gamma line over background (β) is not large (β=5 -10). There is the value

β = 8 – 10 for continuum. The gamma spectra obtained during burning the discharge and after turning off were processed for identifying gamma lines of radioactive nuclides using database [2]. The analysis showed that the nucleuses having the neutron excess with mass of from A=16 to A=136, giving β- radioactive decay chains were gamma – radiators. The example of this chain for atomic mass of A=102 are given below. All the gamma lines given in this chain were registered in the experiment.

Taking into account the values of gamma – line areas, the value of detector efficiency, the value of quantum yield the absolute quantity of radioactive atoms were defined. The -- radioactive chains with masses of A= 16; 17; 23; 30; 46; 47; 51; 54; 55; 58; 63; 64; 71; 75; 80; 84; 92; 97; 99; 100; 101; 102; 103; 104; 105; 106; 107; 108; 109; 110; 118; 123 give the main contribution to gamma – radiation (operating time for radioactive nuclides are up to 10^5atoms). There are the decay channels with fast neutron emission for some of these chains.

n,(31%)	n,(2,37%)	n,(1,94%)				
-,32ms	-,118ms	-,448ms	-,2.1 s	-, 7.1s	-, 14.61m	-, 14.22m
^{101}Rb	^{101}Sr	^{101}Y	^{101}Zr	^{101}Nb	^{101}Mo	^{101}Tc	^{101}Ru
, keV 111.6	128.3	98.3	119.3	157.5	191.9	306.85
271.2	163.4	118.7	140.6	180.7	533.5	545.06
251.6	474.1	216.9	373.9	276.1	590.9	623.8
363.1	510.7	133.8	597.8	280.2	1012.5	489.1
92.8	590.4	104.4	597.8	294.6	713.0	344.0
232.7	666.6	146.9	722.2	466.35	1599.3	
1091.8	694.3	661.8	912.2	810.8	1590.1	
1362.9	744.1	668.7	1095.8	797.1	1759.8	
	1124.8	729.7	1924.5	1042.6	2032.1	
	1062.9		2009.5		2041.2	
	2565.4		1957.6			

IV. REGISTRATION OF IMPURUTY NUCLIDES

The analysis of the impurities content in the cathode samples material before and after the experiments when using the device of the high-current glow discharge [1]. was made in the experiments carried out before, assuming that the recorded excess heat [1] was connected to the running nuclear reactions [2]. The following methods were used: spark mass spectrometry, secondary ionic mass spectrometry, and secondary neutral mass spectrometry. This technique was used for analyzing the impurity nuclides in the cathode samples material before and after the experiment. The difference in the content of the impurity elements before and after the experiment was defined as storage of the elements during the experiment. The elements impurities with the mass being approximately twice less as Pd mass and with the mass close to Pd mass were recorded in the near-surface layer having the thickness of 1000nm in amount up to some tens percents. The main impurity elements were (with the contents more 1%) ^{7}Li, ^{12}C, ^{15}N, ^{20}Ne, ^{29}Si, ^{44}Ca, ^{48}Ca, ^{56}Fe, ^{57}Fe, ^{59}Co, ^{64}Zn, ^{66}Zn, ^{75}As, ^{107}Ag, ^{109}Ag, ^{110}Cg, ^{111}Cg, ^{112}Cg, ^{114}Cg, ^{115}In. The impurity content in the cathode volume sample in different depths was defined.

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The procedure of the impurities definition by the method of the secondary ion mass spectrometry included the following operations (Fig.9): removal the upper defect layer with the thickness of 1.5nm by the method of plasma etching, scanning the first and second layers in 5nm with defining the content of the impurity nuclides, removal the layer with the thickness of 700nm and repeated scanning of the third and fourth layers in 5nm with defining the content of the impurity nuclides (Fig.10).

The elements impurities with the mass being approximately twice less as Pd mass and with the mass close to Pd mass were recorded in the near-surface layer having the thickness of 100nm in amount up to some tens percents.

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Table 1.

A Impur. nuclide	1 scan 10 nm, content %	2 scan 50 nm, content %	3 scan 700 nm content %	4 scan 800 nm content %
^{6}Li	0.075	0.22	0.21	0.16
^{7}Li	0.84	0.53	0.45	0.47
^{11}B	0.14	0.31	0.18	0.18
^{12}C	0.93	0.63	0.47	0.54
^{13}C	0.19	0.15	0.05	0.06
^{20}Ne	0.14	0.27	0.14	0.16
^{42}Ca	0.72	1.14	1.08	0.8
^{44}Ca	2.0	3.2	3.1	2.6
^{45}Sc	0.74	0.91	0.86	0.8
^{46}Ti	0.57	0.72	0.52	0.7
^{47}Ti	0.25	0.14	0.31	0.14
^{48}Ti	1.1	1.23	1.1	0.66
^{52}Cr	0.62	0.41	0.31	0.1
^{56}Fe	2.9	2.6	3.1	2.7
^{57}Fe	5.5	3.25	3.53	3.16
^{59}Co	1.0	1.0	1.4	1.5

A Impur. nuclide	1 scan 10 nm, content %	2 scan 50 nm, content %	3 scan 700 nm content %	4 scan 800 nm content %
^{71}Ga	4.0	4.9	5.6	3.4
^{72}Ge	5.1	4.4	5.1	6.0
^{75}As	6.2	4.9	7.4	4.7
^{77}Se	3.4	3.9	4.8	4.0
^{78}Se	4.5	3.45	5.8	1.4
^{79}Br	3.0	2.4	2.8	2.3
^{80}Se	4.0	3.4	2.5	2.3
^{82}Se	3.4	3.0	2.8	3.2
^{85}Rb	2.2	3.4	3.3	3.6
^{88}Sr	3.1	4.4	4.2	6.0
^{90}Zr	2.4	1.5	2.3	5.8
^{111}Cd	2.8	3.0	3.0	3.4
^{112}Cd	3.4	3.2	4.2	4.5
^{113}Cd	4.0	1.8	2.8	5.1
^{114}Cd	4.7	3.9	3.3	3.6
^{115}In	2.2	2.5	2.3	

^{66}Zn	0.21	0.43	0.54	1.0						

The results of these measurements show, that production of the impurity nuclides occurred in the volume of the cathode sample material in depth up to 1000 nm (up to 4000 atom layers) from the cathode surface.

V. X-RAYS REGISTRATION

The intensive X-ray emission from the solid medium of the cathode samples was recorded under the experiments. The recording of the X-rays was carried out using thermoluminiscent detectors (TLD), an X-ray film and scintillator detectors with photomultipliers [1].

The thermoluminiscent detectors (TLD) on the base of Al_2O_3 crystal, which allowed recording the values of penetrating radiation, starting from the background values of the environment radiation, were used with the purpose of measuring the intensity and evaluating the average energy of the soft X-ray emission from the cathode

The detectors in the form of disks with a diameter of 5mm and thickness of 1mm, closed by beryllium foil of the various thickness (15□m, 30□m, 60□m, 105□m, 165□m, 225□m и 300 □m) were arranged above the cathode in the special cassette (seven-channel spectrometer).

The evaluation of the X-ray energy was made according to changing the radiation dose adsorbed by the TLD detectors provided with Be shields of various thickness. The intensity of X-rays passing through Be plate with thickness d was described by the expression: $I = I_0 \cdot 2^{-\frac{d}{d_{1/2}}}$

where: I_0, I – X-rays intensities at the input and output relatively, d – plate thickness, $d_{1/2}$ – thickness of half radiation absorption [2]. The radiation intensity (dose power) was determined as the radiation dose absorbed by the detector and divided by the experiment time. This expression and dependence chart of lg thickness of the half absorption on lg energy of X-rays for beryllium were used for evaluating the X-rays energy. The values of lg thickness of the half absorption from lg energy of X-rays for beryllium were taken from [2], Appendix G.

The radiation dose absorbed by the TLD detectors reduced by the exponent while increasing the thickness of absorbing Be shield. (Fig 11). The main component of X-rays energy was in the range of 1.0 – 1.8 keV. The value of the X-rays energy determined experimentally increased from 1.2 to 1.5keV when increasing the thickness of the Be shield from 15□m to 300 □m (Fig.11). It could be assumed that X-rays was emitted from the volume of the solid-state cathode medium. The part of the radiation from the deeper layers of the solid-state cathode medium lost the initial energy when passing the cathode material. In this case the energy radiation spectrum was displaced to the side of reducing energy. The initial X-rays energy was evaluated as 1.5 - 2.5 keV.

The time X-rays characteristics were studied using the scintillator detectors with the photomultipliers [1].
These measurements showed that X-rays emission was observed as a lot of bursts up to10^9 photons in a burst). The single bursts were recorded after turning off the discharge current within 85ms (Fig 13).

VI. DISCUSSION

The experiments results with the high-current glow discharge carried out for several years allow allocating the basic processes and conditions of their running.
1 –Production of the excess heat power. The excess heat power was produced in the volume of the solid-state medium of the cathode sample under the following conditions:
- - Deuterium should be loaded into the solid-state cathode medium.
- - Initiating excitation of the energy levels of the crystal lattice of the cathode material was necessary.
- - This initiation could be carried out from by a foreign source (for example, by a flow of inert gas ions).
- - The production of the excess heat power occurred mainly in the near-surface layer of the cathode sample with the thickness up to 1 m (by the results of recording the impurity nuclides). The volume density of the excess heat power had a value up to 10^5 W/cm^3.

2- Production of the elements isotopes as an impurity to the basic cathode material.
- - The production of the impurity nuclides occurred in the volume of the solid-state cathode medium presumably as a result of the nuclear transmutation reactions.
- The emission of high-energy heavy ions was not recorded under the experiment. From this fact it was possible to assume, that the nuclear reactions energy was released not as a kinetic energy of the formed impurity nuclides. The impurity nuclides were presumably formed as nuclear isomers (nucleus being in the excited state). From the results of the experiment it followed, that the relaxation of these excited nuclear levels through the gamma- radiation channel was strongly suppressed.

3 - Excitation of the energy levels of the solid-state cathode medium.
- - Formation of the excited energy levels of the crystal lattice was determined by recording the X-rays from solid-state cathode.
- -The X-rays was observed as the bursts of small time duration (presumably up to 10^{-13}s). Each burst contained up to 10^9 x-ray quantums with the energy of 1.5 - 2.5 keV. The bursts were recorded in amount of up to 10^5 bursts in a second during the discharge burning and within 100ms after turning off the current.
- - Hypothetically, the mechanism of forming this radiation was the following. When bombarding the cathode surface by the discharge plasma ions in the solid medium, the excited energy levels with the energy of 1.5 - 2.5 keV and lifetime up to 100 ms were

formed. Looking into the concrete physical mechanism of forming these levels requires some additional researches. It is possible to assume existing one of the two possible physical phenomena. 1- Oscillatory deformation of the electron-nuclear system of the solid ions. The core of electronic shells was displaced from a nucleus with forming a dipole (optical polar phonon).

2- Excitation internal L, M electronic shells without ionizing the external electrons. • - The relaxation of the excited energy levels of the solid medium occurred by emitting the X-rays and maybe, fast electrons.

• - Hypothetically, the relaxation of the excited levels occurred simultaneously from the volume of micro monocrystals making the solid medium. In other words, totality of the excited ions of the micro monocrystal relaxed simultaneously and gave the X-rays burst.

4- Nuclear transmutation reactions. The excited energy states with the population density of n_{exit} (cm^{-3}) and characteristic temperature of T_{exit} ≥ 1.5 – 2.5keV and more (up to 20 000 000 °K and more) were formed in the solid after every passing the pulse of the glow discharge current. These energy states existed for the characteristic time τ_{exit} (up to 100 ms and more). Such medium in which the temperature of the crystalline lattice did not exceed some hundreds °K we call a non-equilibrium medium.

• - Carrying out the non-equilibrium nuclear transmutation reactions was possible in such medium. Probability of running these reactions (and accordingly the value of the excess heat power) was determined by criterion:

$$n_{exit} \cdot \tau_{exit} > (n_{exit} \cdot \tau_{exit})_{min}.$$

This criterion was a modified Lawson's criterion used for estimating the positive heat output at inertial thermonuclear synthesis.

• - The population density was defined by the parameters of the discharge burning and the cathode sample geometry. The characteristic time of existing the excited states was defined by the balance between the processes of the energy levels excitation when passing a pulse of the pumping discharge current and processes of these levels relaxation by emitting the X-rays. Thus, for obtaining large quantities of the excess heat power it was necessary to create the high population density of vibration- dipole energy states n_{exit} and to suppress the X-rays emission (for increasing a lifetime of the excited states τ_{exit}).

5 - The following types of the nuclear transmutation reactions resulting in formation of the stable nuclides were possible:

$$A + mB \rightarrow [AB]^* \quad (2)$$

$$[AB]^* \rightarrow F^* \rightarrow F + Heat \quad (3)$$

$$[AB]^* \rightarrow C^* + D^* \rightarrow C + D + Heat \quad (4)$$

where A - Pd or other element nucleus; B- deuterium or hydrogen; [AB]* - short-lived intermediate compound nucleus; m-1,2,3..., C*, D* - nuclear isomers of nuclides with masses less than Pd one; C,D - stable nuclides, F - a nuclide with mass more than Pd

one. First a composite compound-nucleus in the excited state was formed. Then one of the two possible modes was realized:
1) The compound-nucleus could lose its excitation and formed a stable nucleus being heavier than Pd one; 2) the compound nucleus could be fissionable into two nuclei-fragments with masses less than Pd one. In so doing the two nuclei should be in the excited isomer state (experiments showed that the nuclear reactions energy was not produced as a kinetic energy).
6 – The specific physical mechanism of carrying out these reactions requires some additional researches. One of the possible types of these reactions with forming the impurity nuclides can be long-ranged (resonant) nuclear reactions. The mechanism of the long-ranged reactions can be considered by the example of the specific transmutation reaction (Fig.14). Forming a lot of ^{13}C nuclide was recorded under the experiments. A possible reaction can be the following.

$$^{104}Pd + {}^{2}D \rightarrow {}^{106}[Pd;D]^* \rightarrow {}^{13}C + {}^{93}Nb + 7.820\ MeV; \qquad (5)$$

According to the laws of pulse and energy conservation, the formed nuclide ^{13}C should receive the energy of 6.8608 MeV. The nuclide ^{93}Nb should receive the energy of 0.959 MeV. The nuclear excited state (a nuclear isomer) with the energy of 6.864MeV and excited level width of 6keV existed for ^{13}C.The excited level with the energy of 0.9498MeV existed for ^{93}Nb. The difference between the energy received by nuclide ^{13}C and the energy of one of the excited nucleus state was equal 3.2keV. At the excitation energy of the crystalline lattice of 1.5 and width of the excited energy level of 6.0, these conditions gave a high probability of carrying out the long-ranged (resonant) nuclear reaction (Fig. 14).
The totality of the experimental results allows assuming, that the energy of the excited nuclear levels of the formed nuclides converses into heat. The specific physical mechanism of such conversion requires additional researches.

IV. CONCLUSIONS

The obtained results (the glow discharge device giving the excess heat power up to 5 W/cm^2 at the efficiency up to 150 %) allow developing a demonstration source of heat power. The technology of multi-element cathode fuel elements with plasma anodes has been developed. The demonstration reactor with the input electrical power of 10kW and output heat power of 15 kW will have dimensions of $20 \times 20 \times 20\ cm^3$.
Development of a new nuclear engineering is possible on the base of non-equilibrium nuclear transmutation reactions in the solid-state medium. This type of engineering can be called "Third way" in nuclear engineering in comparison with the nuclear engineering on the base of uranium nucleus fission and thermonuclear synthesis.

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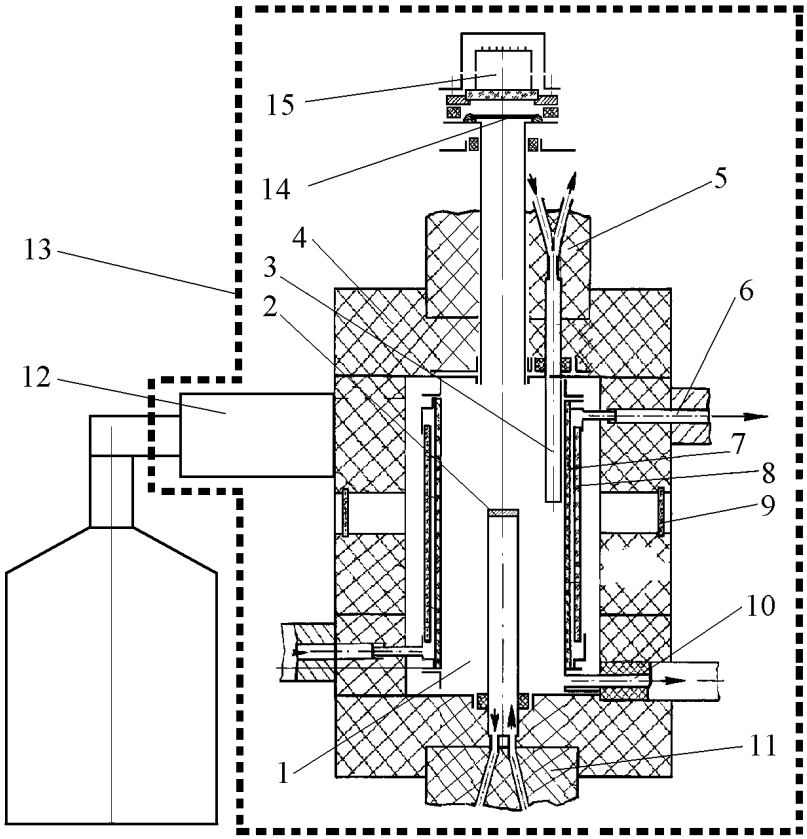

Fig.1. Experimental Glow Discharge Device (flow continuous calorimeter). 1 – vacuum discharge chamber, 2 –cathode unit. 3 –anode unit, 4 –thermal insulation cover, 5 – insulation of the anode cooling system, 6 - the chamber cooling system, 7 – the discharge chamber tube, 8 – the chamber cooling jacket tube, 9 – windows in thermal insulation cover, 10 - the vacuum hose, 11 - insulation of the cathode cooling system, 12 - HPGe gamma detector, 13 - 10 mm thickness led shield, 14 - 15 Be window, 15 - X-ray detector.

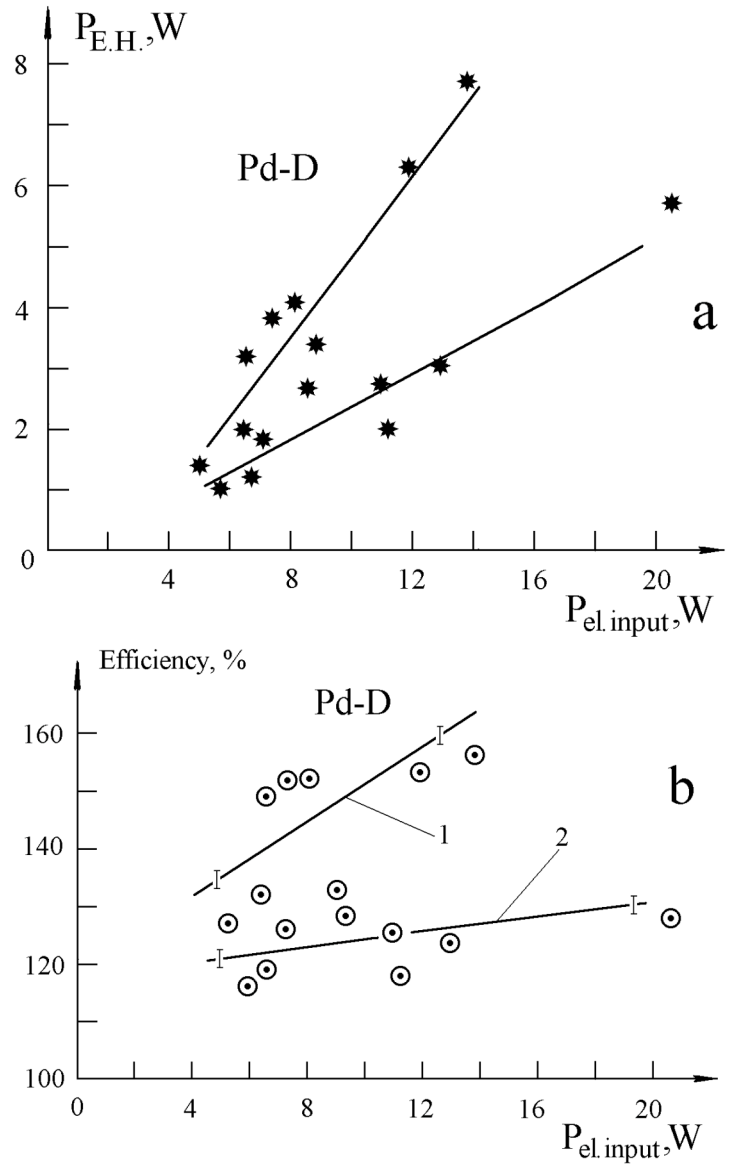

Fig.2. Excess Heat Power in relation (a) and Efficiency in relation (b) to the input electric power. Cathode sample - Pd, d = 9 mm, gas - D_2 **;** 1- D_2 -charged Pd with D_2 loading and unloading, 2- D_2 -charged Pd without D_2 loading or unloading

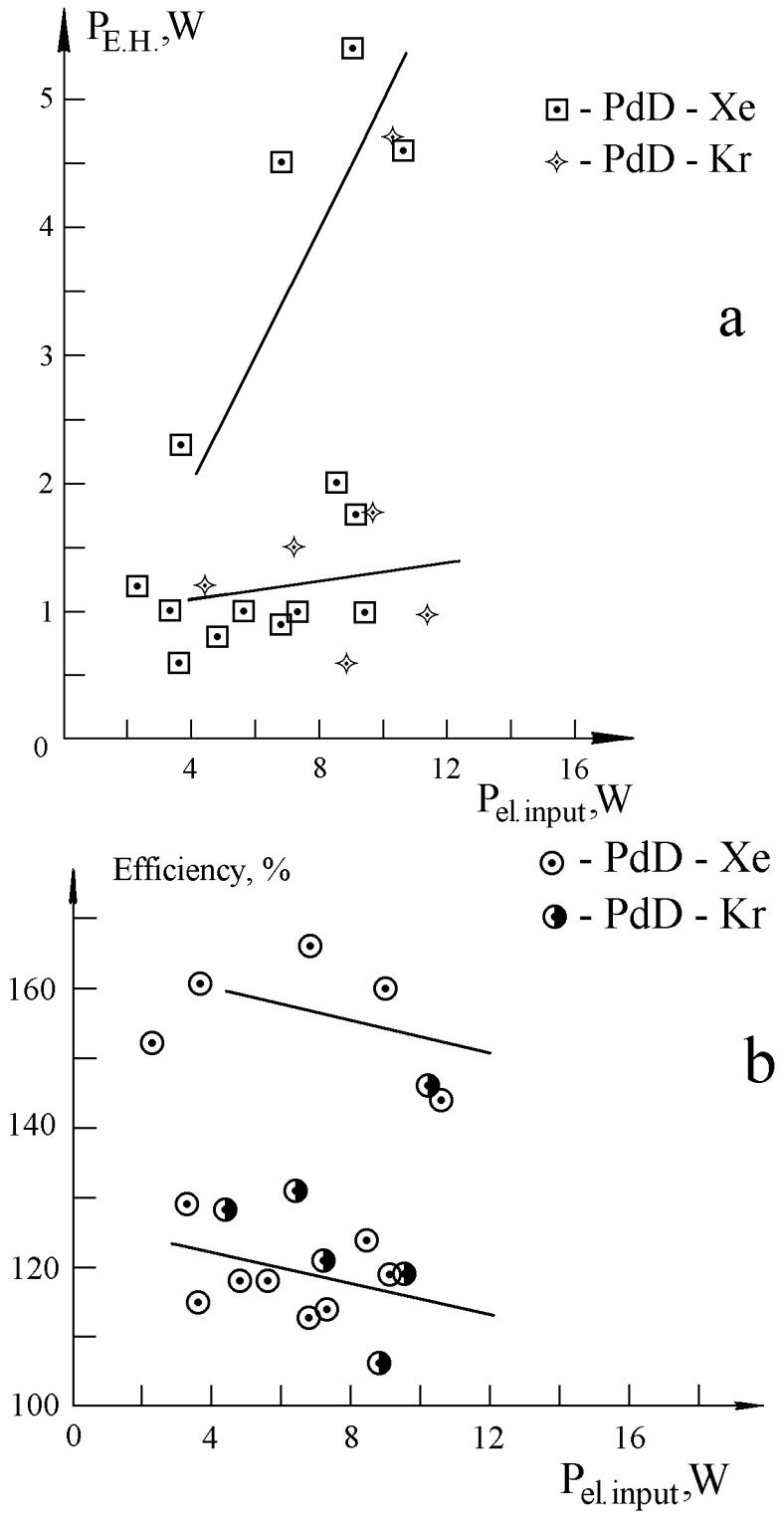

Fig.3. Excess Heat Power in relation (a) and Efficiency in relation (b) to the input electric power. Deuterium-charged Pd cathode samples in Xe and Kr discharges, d = 9 mm. 1- D_2 -charged Pd with D_2 loading and unloading, 2- D_2 -charged Pd without D_2 loading or unloading.

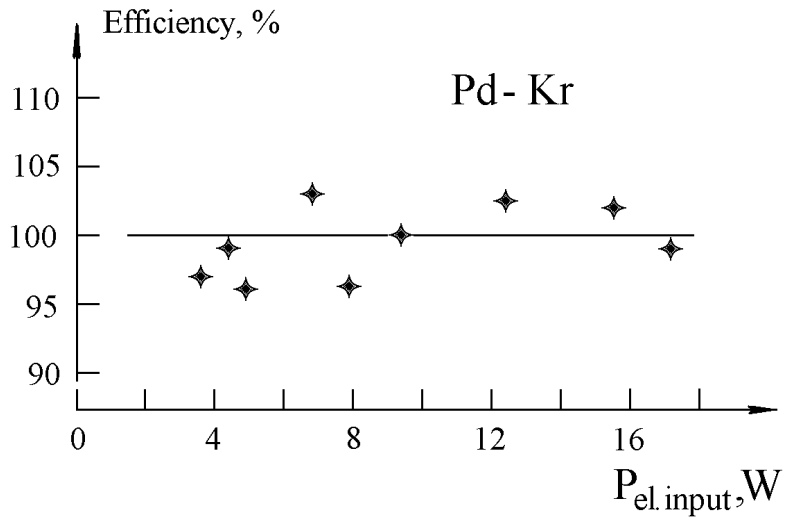

Fig.4. Efficiency in relation to the input electric power. Not deuterium-charged Pd cathode samples in Kr discharges, d = 9 mm.

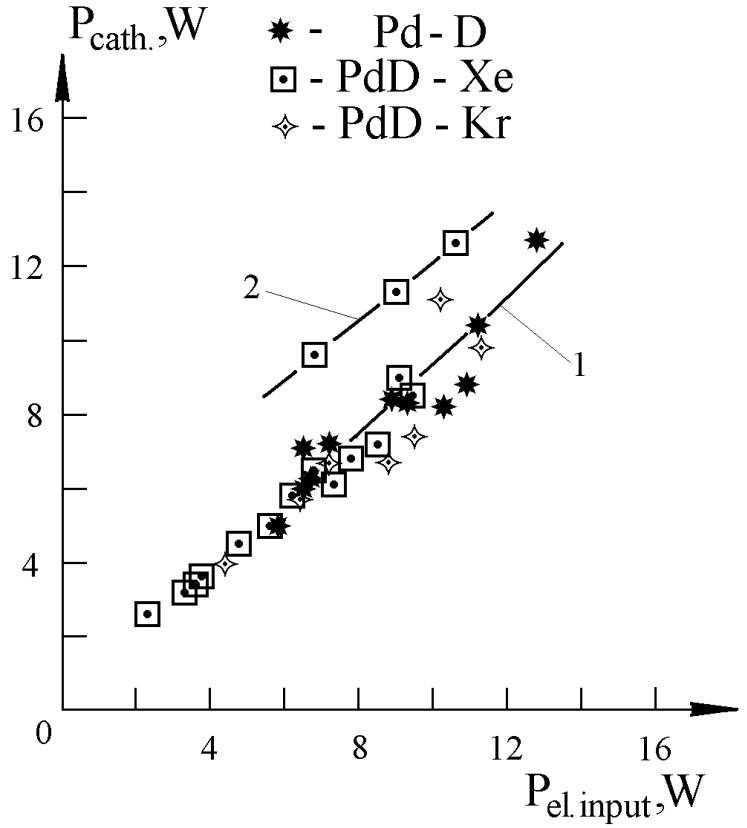

Fig.5. Excess Heat Power of cathode in relation to the input electric power for. Pd cathode in D and deuterium-charged Pd cathode samples in Xe and Kr discharges.

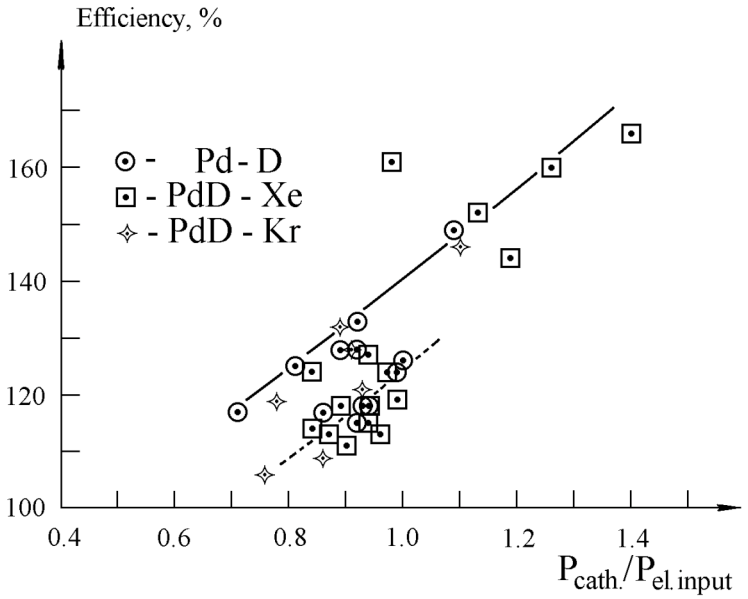

Fig. 6. Dependence of excess heat power and efficiency on parameter: relation of heat power released on cathode to electrical power input into discharge. 1- D_2 -charged Pd with D_2 loading and unloading, 2- D_2 -charged Pd without D_2 loading or unloading.

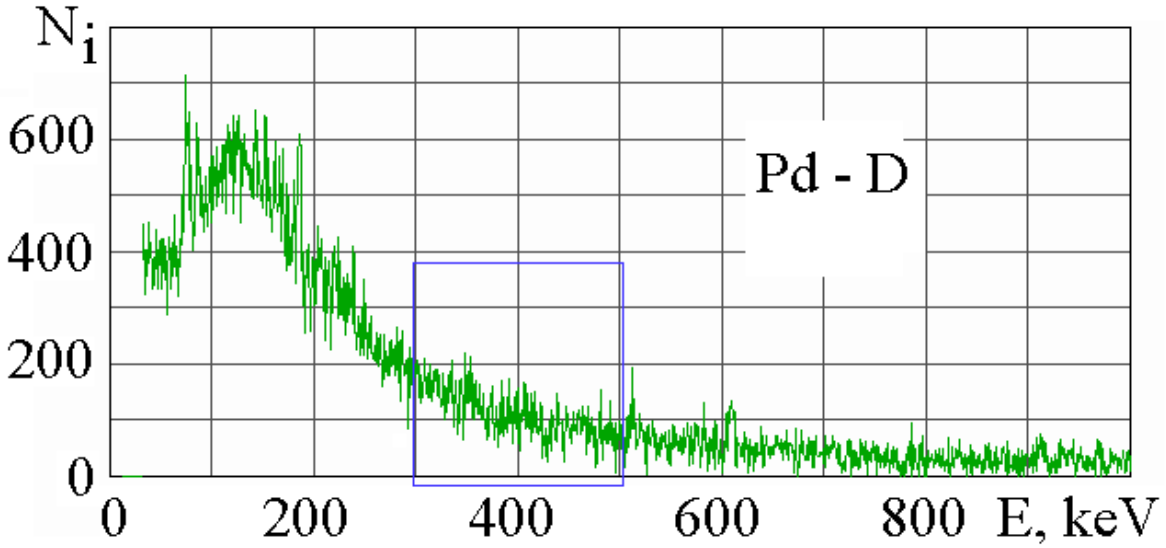

Рис. 7. Post- Glow Discharge induced back ground corrected gamma-emissions spectra by Ge-Li detector after switch off glow discharge current, exposition time is 60000 s. Pd - D2, I = 100 mA, U = 900 V.

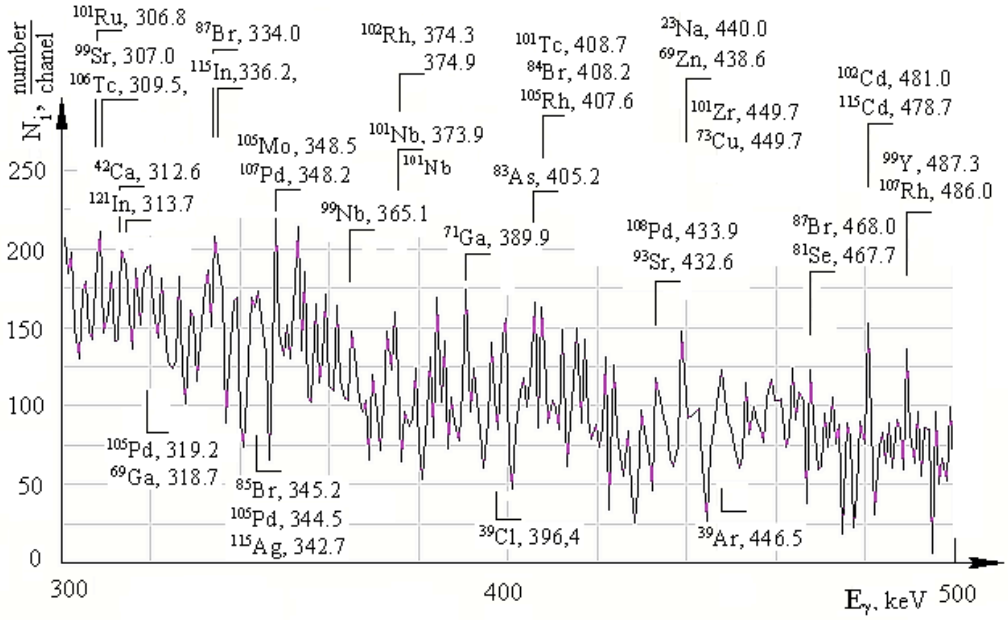

Рис. 8. 300 - 500 keV area of Post- Glow Discharge induced back ground corrected gamma-emissions spectra by Ge-Li detector after switch off glow discharge current, exposition time is 60000 s. Pd - D2, I = 100 mA, U = 900 V.

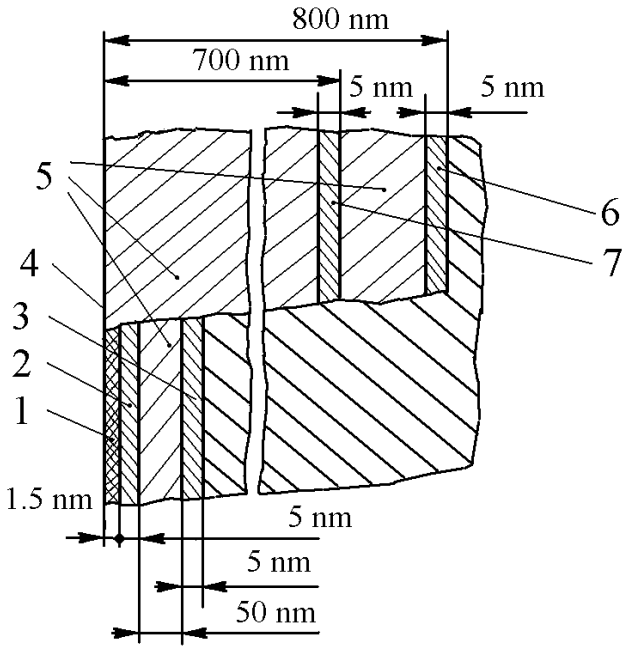

Fig.9. Registration procedure for the impurity contents in the cathode samples (methods SIMS and SNMS). 1-dirty superficial layer, 2,3-analyzed layers, 4-surface of the cathode samples, 5-removal of a metal layer, 7,6- analyzed layers.

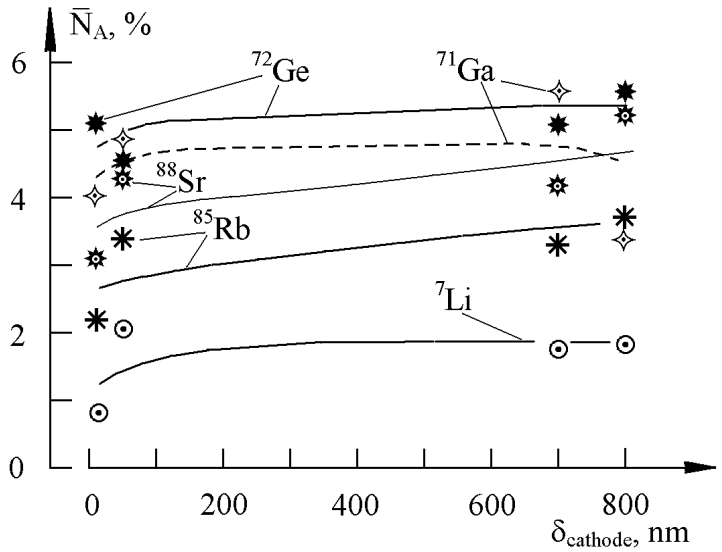

Fig.10. Variation of some isotopes content in the surface layer Pd – the cathode after discharge, System Pd – D2, current –100mA, time of the experiment – 22 hours.

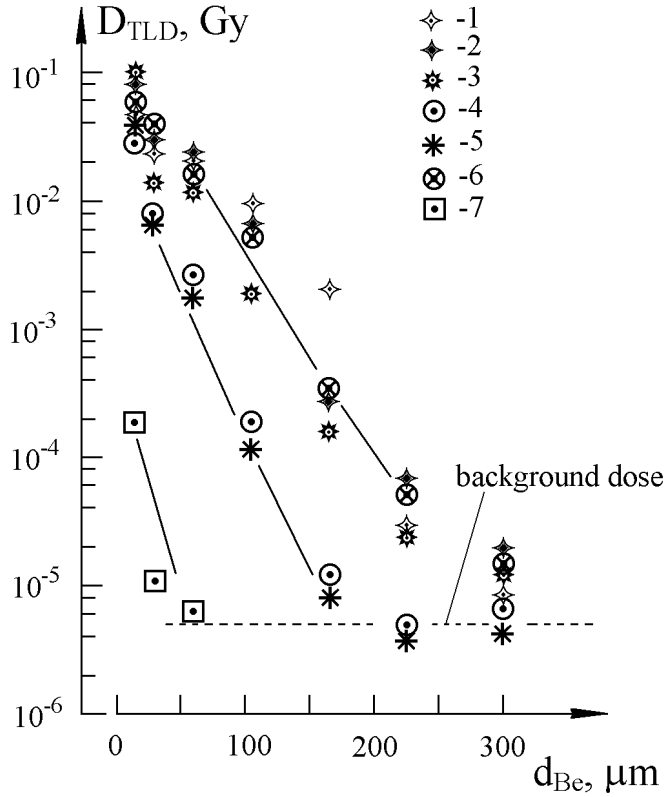

Fig.11. The X-ray dose absorbed by TLD detectors covered with Be foil with the different thickness. Pd-D system, current –200mA, the exposure time – 6000s. 1 - discharge voltage is 1750V, 2 -1770V, 3 - 1650V, 4 - 1530V, 5 - 1400V, 6 - 1250V, 7 - 800V.

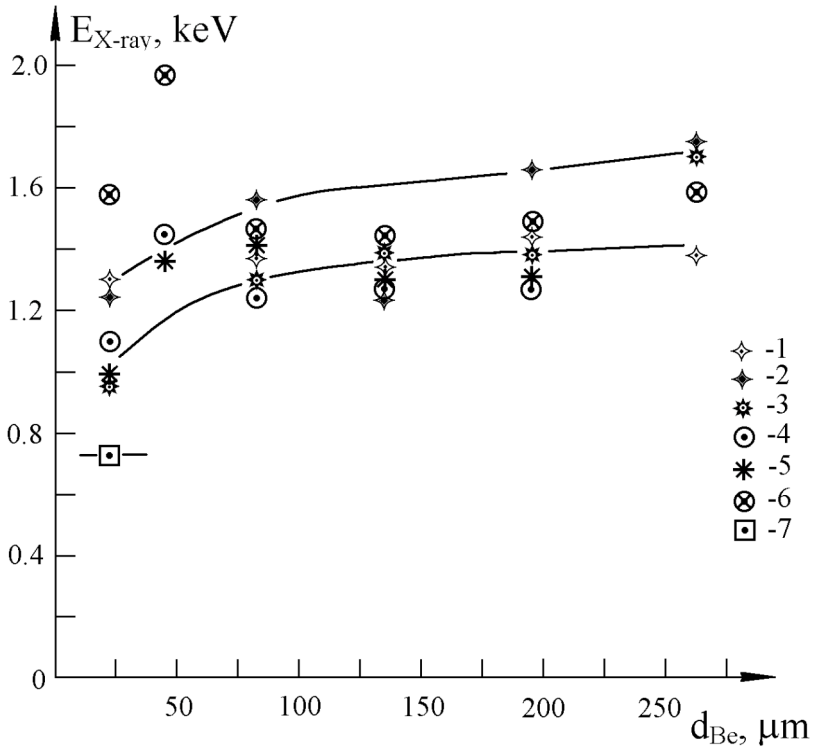

Fig.12. The X-ray emission energy dependence upon the discharge voltage (TLD detectors with Be foil shields measurement). 1 - discharge voltage is 1750V, 2 -1770V, 3 - 1650V, 4 - 1530V, 5 - 1400V, 6 - 1250V, 7 - 800V.

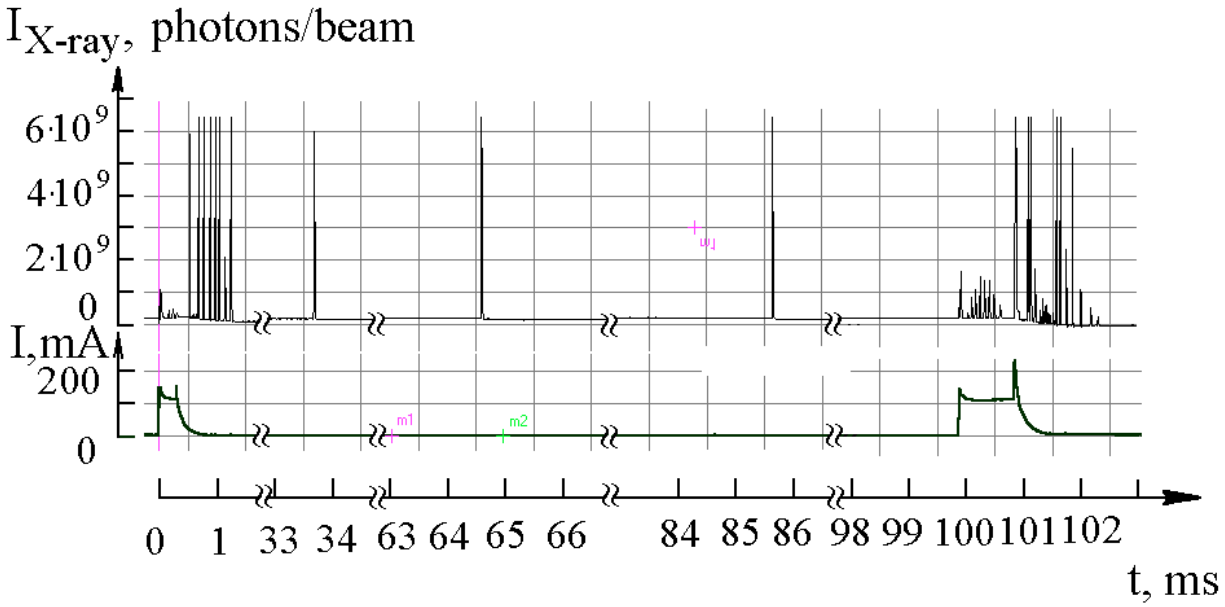

Fig.13. Typical oscillogram of X-ray bursts within long time interval after turning off the discharge current.

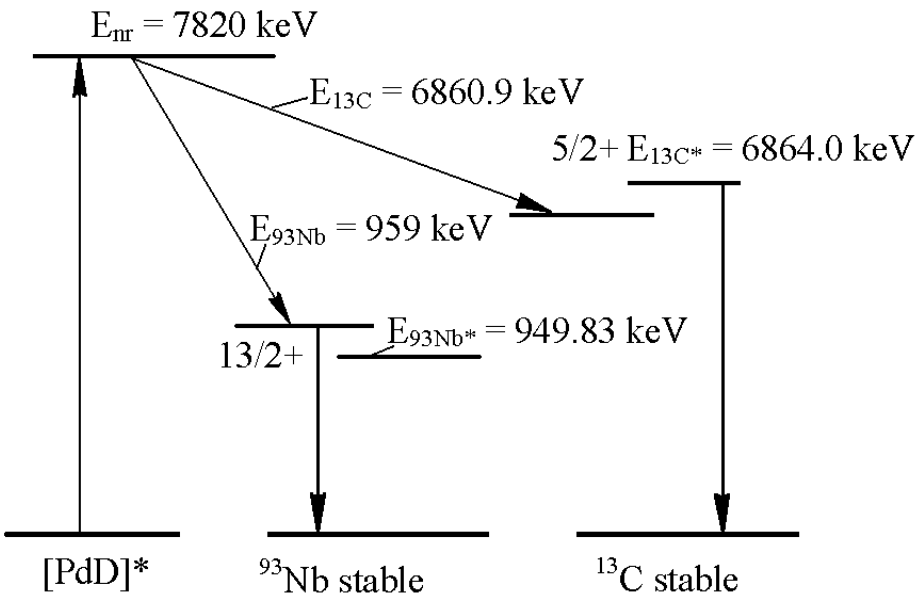

Fig. 14. Assumed plan of carrying out long-ranged (resonant) nuclear reactions.