# ELEMENT-PHASE TRANSITIONS WITH THE COLD NUCLEAR SYNTHESIS (CNS) TYPE REACTIONS IN METALLIC ALLOYS OF GLASS-FORMING SYSTEMS

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In spite of great interest in the mechanisms of CNS (cold nuclear systems) and its ecological and material science application aspects, the information up to now about such reactions in metallic systems, beside deuterides, is contradictory. The present research is devoted to the analysis of the results of experiments, the foundation conditions and mechanisms of CNS reactions by the examples of metallic alloys of glass-forming systems. The choice of objects under investigation is connected with their nonergodic behavior in all interval of their existence. The last is the necessary condition for the observation of the CNS-reactions when there are strict volume and kinetic limitations on the phase-transition processes.

The investigation of the CNS reactions was carried out by using the glass-forming metallic alloys of "metal-metalloid" system Fe-Ni-P-C and "metal-metal" Cu-Zr system. The essential levels of volume and kinetic limitations, and the corresponding degree of non-equilibrium in phase transition were achieved by electro-impulse compactation of power samples with heating under pressure up to 10JPa. The method of experiment is close to that described in [1].

The X-ray diffraction analysis of samples was done by DRON-2,0 (Cu K420); the election microdifraction (by powdered method) -by [Russian word]-100K (U=70kV); the cross-section surface investigation of the samples and X-ray spectrum microanalysis were done by scanning electron microscope JSM-35, with the spectrometre of the KEVEX-5100 type; the quantitative X-ray spectrum microanalysis and Auger-electron spectroscopy (XSMA and AES) were done by NB-100; the secondary-ion mass spectrometry (SIMS) by Cameca IMS-4F; the chemical analysis of the initial rod and powder were done by atomic-absorption spectrometer; and the registration of the presence of transition radiation was done by [Russian word]-70 apparatus.

For the initial powder samples composition Fe(70)Ni(10)P(13)C(7) after impulse treatment the presence of at least two (2) hexagonal closely conjugated lattices was revealed by X-ray diffraction, and one of them was identified as WC-lattice. Aliquot increase of lattice parameters, fixed by X-ray diffraction, shows the evidence of scaling (reproduction of the same structure on more and more increasing scales.)

Faceted crystals of WC on the surfaces of impulse-treated samples are seen without any optical magnification (Fig. 1a). By XSMA and AES methods (Fig. 1b) the element content of faceted crystals and matrix were determined. They are as follows: W(6)Fe(40)Ni(40)C(14) - matrix; Fe(2,25)Ni(2,25)W(46,5)C(50) - inclusions. Caverns of gas bubbles exiting are distinctly seen on the faceted surfaces. The results of SIMS (Fig. 2a) confirm the results of XSMA, AES and chemical analysis. The lines of all isotopes of elements fixed are present (with the changing of intensity of isotope lines Fe and Ni on mass spectrum of treated samples as compared with initial). Strong lines of hydrogen are (H) also present on the mass-spectrum of the treated samples. The groups of lines corresponding to the isotopes with masses 2Fe(56), Fe(56)Ni(58) must be noted. The line shifting of KLL-series Fe (2.5-1.5 eV) to the high-energy side, the appearence of the additional transition lines with the energies of 776 eV and 585.7 eV; the additional transition lines relative intensity is more than 5 times; the splitting of several peaks; the shifting carbon KLL series at 3.9 eV to the high-energy side in matrix - all this is evidence for the existence of strong-bounded molecular complexes in the treated samples. It must be pointed out that the amount of WC in the samples after the treatment is exactly the same as (Me)(3)P in the initial ones, and phosphorus is absent in the treated samples. Taking into consideration the balance of elements, it is possible to present the reaction:

$$\frac{199}{(Me(3)P)} \rightarrow (WC)^{199} + H^{1} \quad \text{with variation of isotope masses.}$$

The X-ray diffractional analysis of the impulse treated samples made of amorphous powder with the initial composition of Cu(60)Zr(40) shows the preservation of the amorphous structure after the treatment. The qualitative XSMA of the samples cross-sections from the depth of 1000 Å revealed Co, Sm, Fe and slight amounts of Cu and Zr. SIMS (primary ion beam 05 ± 0.6 keV) results confirm these data (Fig. 2b). There are also lines of ions of light elements with M/Z ratio from 1 to 12.

The quantitative Auger-spectrum analysis samples cross-sections gives the data (the whole surface): 19 at.% Sm, 42 at.% Co, 2 at.% Fe, 10 at.% Cu, slight amounts of B, about 23 at.% $O_2$ in oxides and about 4 at.% C in carbides (according to the form of spectrum lines). It must be noted that there are variations of element's content in different regions.

The shifting of KLL Co series for 1.5 - 2 eV, MLL Sm series for 3 - 4.9 eV to the high-energy side; 2.5 times line broadening of Sm in comparison with pure element may be interpreted as a residual excitation. Based on these data the main reaction may be written:

$$Cu_2^{63,65}\ Zr^{90,91,92,94} \rightarrow Co^{59}\ Sm + X,$$

were X are light elements with masses from 1 to 12.

As a result of convection processes in the melt and in correlation phase transition (called vitrification) [2] in alloys under investigation the hierarchy of structural topological subsystems is formed in them according to the scaling rule. The sizes of non-uniformities stretch from several hundreds to about ten Å [3,4]. Each topological subsystem contains its own dynamic soliton subsystem. A number of subsystems depends on the method of fabrication as well as on the alloy composition. The smallest scale structural subsystems may by considered polyhedral chains, and each of these polyhedrons may be considered as a quasi-molecular complex. It must be pointed out, that when spinning the formation of subsystems hierarchy may be described by soliton solutions of KDV - equation, which possess the properties of Toda lattices (hierarchy of lattices placed one into another).

The conduction of the current impulse of sufficient magnitude leads to the high-power soliton envelope formations and all soliton modes of all subsystems appear to be in the own modes of such soliton envelopes. Due to this fact, the resonance connection of subsystems with a high coefficient of transmitting is possible (if to take into account high-frequency oscillating soliton "tails"). The superposition of the soliton envelope with the coherent phase transition front in the quasi-molecular complex determines "energy depth" of the last transformation. When analysing the transition process, the quasi-molecular complex in the range of crucial effects is considered as an ensemble of dynamic structures, which demonstrates a particular number of variations in the ensemble in transition to a new steady state. The results of the numerical modeling of discret Ginsburg-Landau equation, for example, may illustrate the behaviour of such a system.

The consecutive excitation of intrinsic degrees of freedom in quasi-molecule - it means the appearence of pulsing precession of electron orbits under variable electromagnetic field of soliton envelope influence. The range of crucial effects may be described on the basis of an improved Bohr's atomic model. In this improved model, orbital currents interact with constants different from those of classical electrodynamics [5], and they are considered as parameters of stability in stationary solutions of self-oscillation system's equation of motion.

The transition to the unsteady state result in "overcommutating" of orbital currents in the same way as "blow out" effects proceed in a plasma trap. The effects are accompanied by radiating high-frequency continuous spectrum. Such processes of orbit "overcommutating" are analogous to phase transitions of the second type, which proceed without entropy change, and when expanded to nuclear shells, one can explain the absence of barriers and entropy changes in CNS-reactions.

## REFERENCES

[1] Durachenko A.M., Elagin V.N., Danilchuk A.A., Patent SU 1801059A3, Bull. N9, 1993 (in Russian).
[2] Gotze W., "Liquid-Glass Transition," M., *Nauka*, 1992 (in Russian).
[3] Novicov J.J., Timofeev V.N., Sofronova R.M., Thes. of sympos. "Electron Microscopy and Electronography in Investigation of Creation, Structure and Properties of Condensed Matter," M., 1983, p 4.
[4] Borbey Sh., Nartova T.T., Tarasova O.B., Thes. of II all-Union conf. "Physicochemistry of Amorphous (glass) Metallic Alloys", M., *Nauka*, 1989, p.183 (in Russian).
[5] Nadycto B.A., Doklady ANSSSR, 1991, vol 316, N6, p 1389 (in Russian).

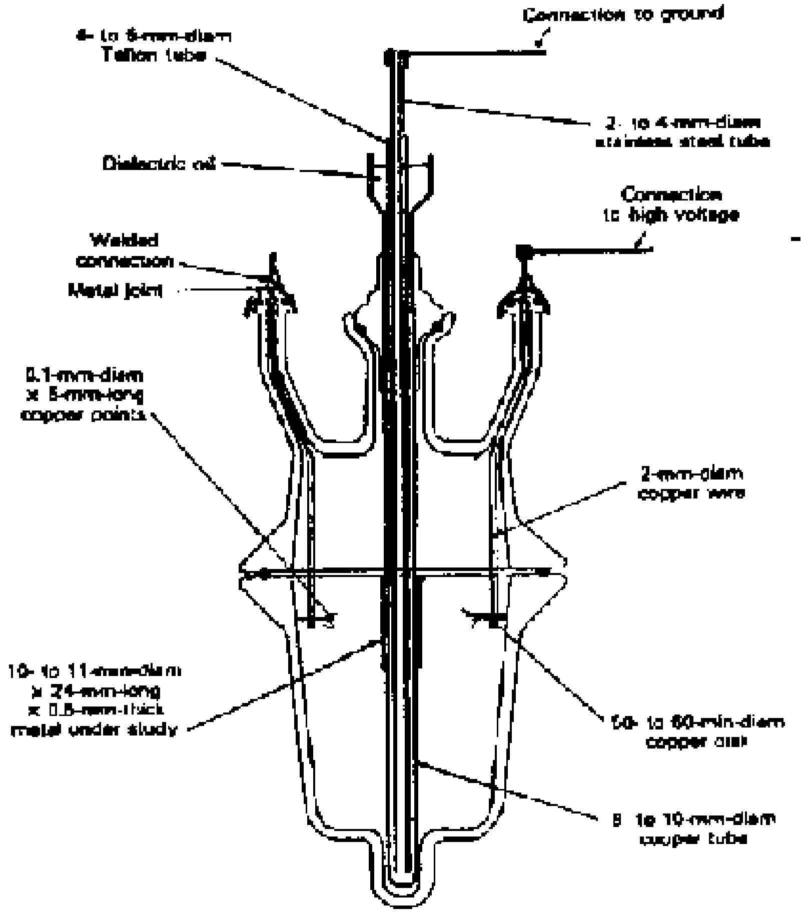

Fig. 1. Reactor.

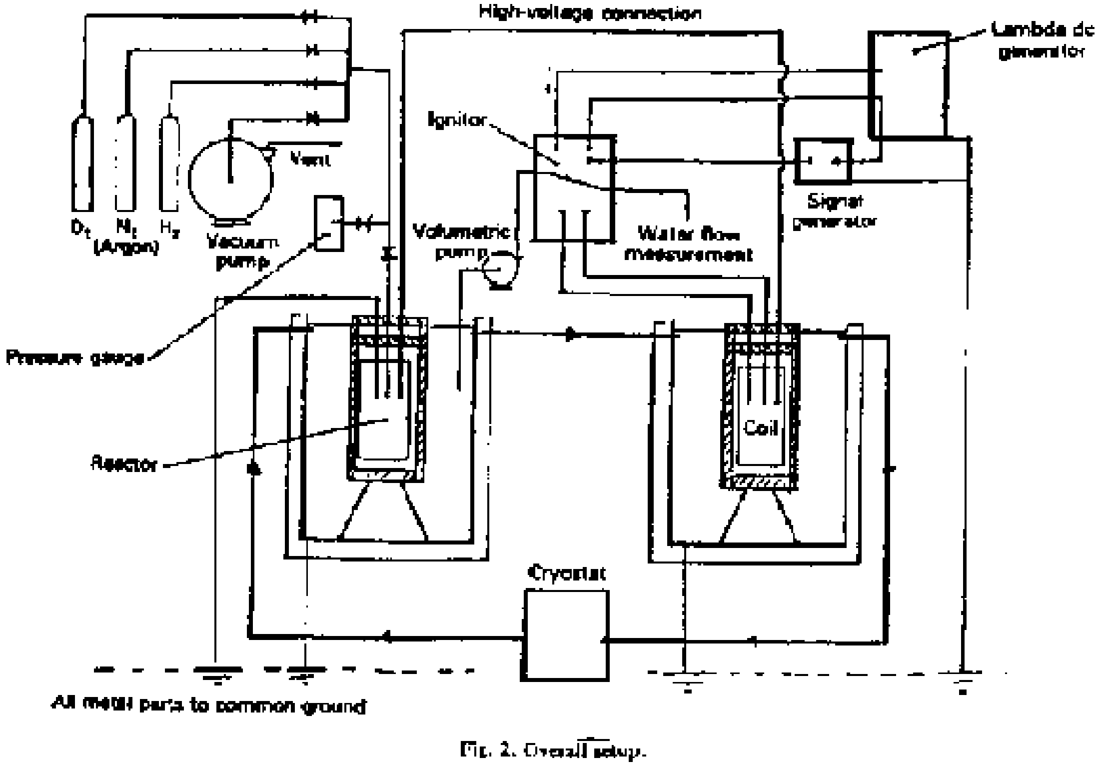

Fig. 2. Overall setup.

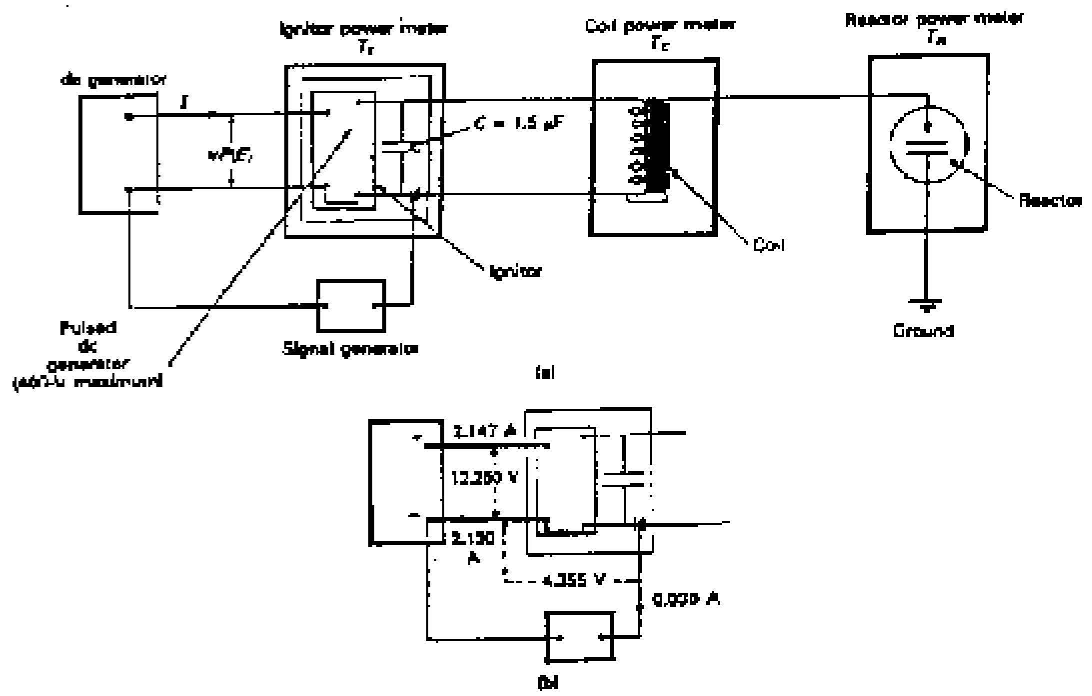

Fig. 3. Electrical supply and power balance.

Fig.4. Excess power in cll experiments

as a FUNCTION of EXPERIMENTS SEQUENCE

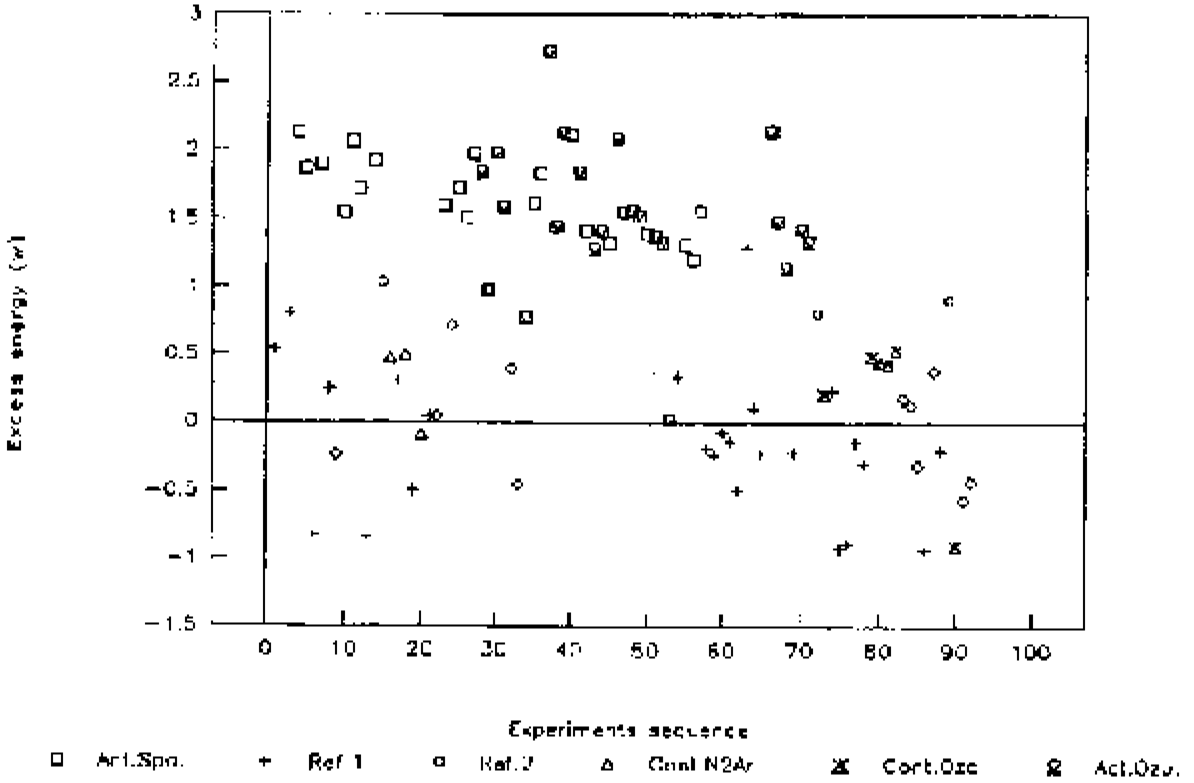

Fig.1. Sample surface (initial alloy FeNiPC) with faceted crystalline inclusion WC (x 500) (a); Auger-spectrum, whole view, central cross-section (b).

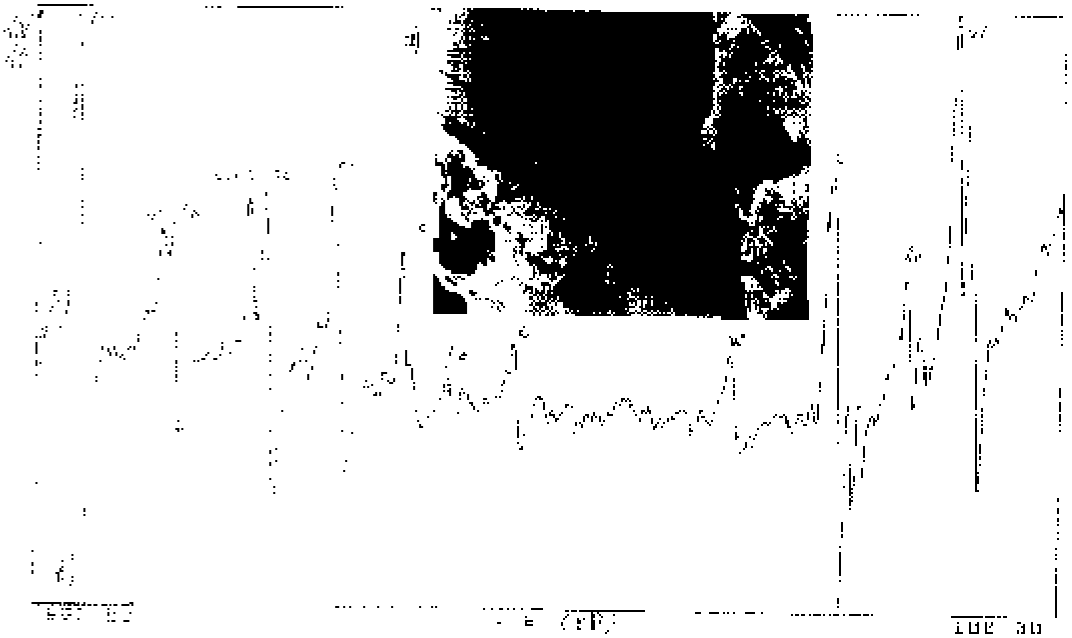

Fig.2. Mass-spectrums of secondary ions of treated samples: FeNiPC - initial composition (a), Cu-Zr - initial composition (b).