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(54) Title: CONTROL SYSTEM FOR NUCLEAR PROCESSES AND COHERENT NUCLEAR FUSION DURING THE EXPLOSIVE BLOW-UP MODE OF SELF- HARMONIZED ELECTROMAGNETIC CONFINEMENT AND METHOD OF ITS IMPLEMENTATION

(57) Abstract:

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CONTROL SYSTEM FOR NUCLEAR PROCESSES AND COHERENT NUCLEAR FUSION DURING THE EXPLOSIVE BLOW-UP MODE OF SELF-HARMONIZED ELECTROMAGNETIC CONFINEMENT AND METHOD OF ITS IMPLEMENTATION

THE FIELD OF THE INVENTION

The invention relates to the technology of controlling nuclear processes and, in particular, nuclear fusion in condensed matter, in which controlled self-consistent pycnonuclear processes, in particular, processes of controlled coherent inertial nuclear fusion, may occur under self-harmonized inertial electromagnetic confinement in the blow-up mode; and to the design of devices for electromagnetic control of nuclear fusion based on relativistic plasma diodes with a system of controlled plasma and virtual electrodes and currents arising during the evolution of the process initiated by a high-voltage potential difference pulse with an appropriate shape applied between the plasma cathode and anode systems after a certain time delay relative to the sequence of moments of the start of the operation of drivers which form plasma components with different energies and the required distribution of electromagnetic fields and currents with different amplitudes in the focusing zone of the electron beam.

With electromagnetic control of nuclear fusion processes, this technology is intended mainly for the transmutation of the nuclei of atoms of some chemical elements into the nuclei of other chemical elements to obtain mainly stable isotopes of chemical elements, including the synthesis of stable transuranic elements, and to process radioactive waste containing long-lived isotopes into materials containing short-lived and/or stable isotopes, for the release of nuclear fusion energy in the form of kinetic energy of fusion products with a certain distribution by composition and energy, electromagnetic fields and currents in a wide range of frequencies, and for the conversion of these various components of the target explosion energy into the thermal and/or electrical form of energy at the output.

TERMS AND DEFINITIONS

target is a single-use dose for impact compaction of at least one arbitrary isotope of at least one chemical element being a raw material for obtaining nuclear transformation products and, optionally, as a primary energy carrier for energy production;

diode or plasma diode is a diode which is a system of electrodes (in particular, these may be plasma electrodes) placed in a vacuum volume (with a certain degree of vacuum, that is, with a certain pressure of a neutral gas) or a volume filled with plasma (generally heterogeneous);

plasma electrode is a consumable part of the negative or positive electrode of a diode that is capable (for a certain time during the discharge pulse) of generating a plasma shell (of the near-surface layer material and injected by special devices) with a near-zero electron or ion work function;

plasma cathode system is a system of one or more (metal, dielectric and/or virtual) electrodes surrounded by plasma layers, from the surface of which electrons are emitted;

virtual electrode is a potential barrier or potential "hole" that arises inside the plasma volume between real electrodes due to the distribution of the spatial charge created by the flow of charged particles in the volume. For example, a virtual cathode partially transmits and partially reflects these particle flows;

concentrator anode is a single-use part of the diode anode that serves as a target and may be at least a single-layer shell made of a solid durable material, inside which a part of the target made of another material is also fixed axisymmetrically to ensure acoustic contact;

focal space is such a volume in the diode vacuum chamber which spatially confines a certain length of the common geometric axis of symmetry of the diode electrodes, and in which (in the absence of obstacles and under pre-set values of the emitting surface area of the plasma cathode, energy of electrons and current density) a pinch of electron beam is possible due to self-focusing of relativistic electrons;

fusion driver is a physical object that delivers energy, which is necessary either for fusion or for fusion control, to the area of fusion processes;

coupled oscillatory systems are oscillatory systems with more than one degree of freedom, which may be considered as a set of separate systems interacting (coupled) with each other;

resonance is the correspondence between the system's spatial and temporal structure and external influence;

system impedance is a value characterizing the inertia and dissipation of the system (the ratio of a force to the velocity caused by this force – the rate of change of inertia);

parametric instabilities are instabilities of oscillating systems, i.e. the exponential increase of the system energy over time caused by the time variation of impedance;

open system is a system that exchanges energy, mass, and information with the environment;

closed system is a system that does not exchange energy, mass, and information with the environment. Energy and information are conserved in closed systems;

structure is a set of system elements with many stable connections between the elements;

dissipative structure is a steady state of an open system resulting from the dissipation of energy that is constantly coming from the outside;

phase portrait means possible states of a system in its phase space. A set of trajectories of a system in its phase space;

phase space (state space) is a multidimensional space the coordinates of which are parameters that fully describe the state of the system;

dissipation is the process of energy dissipation, its transformation into less organized forms;

viscosity is the property of a medium to resist external influence due to internal friction that occurs between parts of the medium. Viscosity is usually positive and due to negative feedback it leads to the transformation of a regular movement into a chaotic (thermal) movement of the medium;

incorrect problems and regularization are problems that are unstable with respect to variations of initial values, which do not allow using standard methods for their solution and require special methods of regularization for their solution;

system's embedding dimension is the minimum number of parameters that fully describe the state of the system;

fractal dimension is the dimension of fractions characterizing self-similarity and scale invariance of systems;

fractal objects are objects that have properties of self-similarity or scale invariance;

mass defect is a change in mass (inertia) as a result of a change in the structure of the system and its connections;

fusion is the process of forming new structures, i.e. the process of forming new connections;

nuclear matter is a model of the medium consisting of nucleons, without taking into account its boundaries;

binding energy (for a given state of the system) is the difference between the energy of the state, in which the constituent parts of the system are infinitely distant from each other and are in a state of active rest, and the total energy of the bound state of the system. For a system consisting of infinitely distant particles that are in a state of rest, the binding energy is assumed to be equal to zero, i.e. energy is released when a bound state is formed. The binding energy is equal to the minimum work required to decompose the system into its components. The binding energy characterizes the stability of the system: the higher the binding energy, the more stable the system is;

confinement means keeping the system of plasma particles in the required state;

magnetic confinement means keeping the system of particles in the required state using quasi-stationary magnetic fields of special configurations;

electrostatic confinement means keeping plasma particles in the required state by electrostatic fields from a stationary electrode system (usually with central symmetry). The

electrostatic field accelerates charged particles toward the center or toward the axis of field symmetry where ions can be retained for a long time. In such a plasma, with radial focusing and central symmetry of the system, virtual electrodes – cathodes and anodes – can appear. They have the properties of real electrodes but practically do not introduce losses into the flows of charged particles circulating through them. Virtual electrodes should be formed in the drift space if the density of charged particle flows injected into the plasma is sufficiently high ($q_{VC} > q_{cr}$);

energy efficiency coefficient Q_W is the ratio of the energy released by a device to the energy consumed to operate this device;

energy efficiency coefficient of the target Q_{Tag} is the ratio of the energy released by a device to the energy delivered to the target;

inertia is the property of a system to maintain its state and resist changes under the influence of excitation;

inertial means based on the use of the system's inertia properties, i.e. connections in the system and their variations;

pycnonuclear process is a process during which, in the interaction between the components of electron-nuclear and electron-nucleon plasmas, in the target substance compressed into a superdense state, there is at least the target isotopic composition change which occurs in the "cold" state of the substance;

inertial confinement means keeping a system of plasma particles in the required state due to the inertia of the system components (due to inertial mass);

impact compression is an isentropic pulse action of a self-focusing density wave that converges on at least a part of the target;

cumulative effect is the concentration of the energy of the explosion in a certain direction, an increase in energy as it moves in a certain direction;

implosion is a physical effect accompanied by energy flows directed inside the system (an explosion directed inside);

superdense state is such a state of at least part of the target after impact compression, in which a significant part of target substance is transformed into electron-nuclear and electron-nucleon plasma;

system control is an external influence on the system (on system parameters) that changes the direction of the system's evolution (i.e., changes the internal structure of the system);

evolution impact $a_P = \frac{\left(P_{dis} / V_{\text{int}}\right)}{\tau_{eff}^2}$ is an acceleration of the power density of the driver

energy absorbed in the near-surface volume of the target during the characteristic time τ_{eff} and the power density of the driver energy P_{dis}/V_{int}, absorbed in the near-surface volume V_{int} of the target during the characteristic time τ_{eff}. This value characterizes the coherent acceleration in the system

acceleration of the power density of dissipative losses $a_T = \frac{n_0 T_{eff}}{\tau_{dis}^3}$, where n_0 is the density of the medium, T_{eff} is the temperature of the medium, and τ_{dis} is the characteristic time of dissipation;

evolution impact coefficient $q_P = \frac{a_P}{a_T}$ it is a dimensionless impact parameter that characterizes the degree to which the power density acceleration of internal energy processes of a system with a regular direction exceeds the power density acceleration of the chaotic component (dissipative component);

mass force is a force that acts equally on all elements of the system and at the same time creates a coherent acceleration of the system. An example of the mass force is the gravitational force which acts on all particles in proportion to their masses. It is usually assumed that the mass force is the cause of the flow in the configuration space of the system. However, in many cases, when the mass force acts equally on all elements of a subsystem (which is somehow isolated from the whole system), it can be assumed that this subsystem, remaining homogeneous in the configuration space, accelerates, i.e., a flow occurs in the momentum subspace of the phase space. An example of such a situation is a subsystem of plasma electrons in an electric field with a strength greater than a certain critical one (the escape threshold). In this case, the plasma enters a state with escaping electrons, i.e., all electrons begin to accelerate coherently, and, in this case, the electric field applied to the plasma plays the role of a dominant excitation acting on the plasma and transferring the plasma electron subsystem to a coherent state. If the flow in the phase space of the system (or coherent acceleration) does not remain constant but is in a state with positive feedback, then the blow-up mode occurs;

dominant excitation is a mass force due to the action of which on the system a flow occurs in the phase space that exceeds the level of the dissipation flow (fluctuations);

electromagnetic means based on the use of electromagnetic interaction, electromagnetic fields, and sources of electromagnetic fields in the system;

beam volumetric charge parameter q_{VC} is a parameter characterizing the achievement of the virtual electrode formation threshold and the virtual electrode existence interval. That is, the parameter that characterizes the excess of the energy density of the Coulomb interaction

over the kinetic energy of the system (the efficiency of self-consistent flow inhibition by its volumetric charge);

electromagnetic field imperfection parameter $q_{EM} = \frac{\rho_{W_p}}{\rho_{W_p} + \rho_{W_{curl}}}$, a parameter characterizing the imperfection of the electromagnetic field and is determined by the ratio of the energy density of vortexless fields ρ_{W_p} to the sum of the densities of vortex fields $\rho_{W_{curl}}$ and potential fields ρ_{W_p}. A coefficient equal to zero (or, more precisely, $q_{EM} \to 0$) corresponds to an ideal state with vortex fields in a vacuum and Coulomb repulsion of the identical charges (the existence of a Coulomb barrier), and an increase in the coefficient $q_{EM} \to 1$ corresponds to a decrease in the repulsion of the identical charges and a decrease in Coulomb barriers;

current electrostatics is the methods and laws of initiating electrostatic fields by non-stationary sources. For example, pulsed currents of special (e.g., toroidal) configurations can be such sources of electrostatic fields of complex spatial configuration. At the same time, the spatial distribution of electrostatic fields is controlled not only by the configuration of the currents but also by the degree of non-stationarity of the currents;

coherence (from the Latin word *cohaerentia*) is the internal connection, interconnectivity, coordinated behavior in time and space of elements within the system, i.e., a coordinated course in time and space of several oscillatory or wave processes. The coherent behavior of elements is the basis for the emergence of spatio-temporal structures. Coherence is inextricably linked to the correlations of the main values in the system. In quantum mechanics, coherent states are states with minimal dispersion (states with a probability distribution in the form of a Gaussian distribution), i.e. states that are closest to the macroscopic states of the system in this sense;

non-local, non-locality means the one that feels the interconnection of all events in the system in general. This is the main characteristic of a system that is in the coherent acceleration mode (blow-up mode). At the same time, the state of the system cannot be given by decomposition by infinitesimal values in the area of a given point and, therefore, by acceleration of the same order. The system is characterized by accelerations of all orders. The property of non-locality is characteristic of systems in the blow-up mode and systems close to a phase transition;

non-local structure is a structure that arises as a result of the process of self-organization, i.e., the evolution of connections in the system throughout its spatial volume, and which differs from the equilibrium one even locally. The self-organization of the system is initiated by mass forces that lead to coherent acceleration (in the absence of significant gradients of macroscopic

parameters within the system). The rearrangement of connections and their energies in non-local structures occurs precisely due to coherent acceleration, provided that both the dissipation energy and the gradients within the system are close to zero;

physical quantity flow in the phase space is the amount of a physical quantity transferred per unit of time through an arbitrary section in space. For coherently accelerating systems, in which the properties are the same throughout the volume, this quantity is not characteristic. A significant quantity within a system that is homogeneous in the coordinate space is the amount of this quantity that is transferred per unit of time through a section in the energy or momentum space. This physical quantity, which does not depend on the coordinates, is the flow in the phase space for coherently accelerating systems. The flow in the phase space (as well as the coherent acceleration) determines the degree of deviation of the state of the system from the equilibrium state which corresponds to the zero value of the flow (or, what is the same, the zero value of the coherent acceleration);

correlation, correlational dependence (from the Latin word *correlatio*) is a statistical relationship between two or more random variables (or variables that can be considered as such with some reasonable degree of accuracy), in which changes in the values of one or more of these variables accompany a systematic change in the values of other variables;

correlated coherent state (CCS) is a complete set of non-stationary states, which can be used to decompose the interrelated processes of localization and delocalization. The equilibrium CCSs that are usually used are adequate to describe systems that deviate slightly from equilibrium (with small accelerations and flows). To describe the processes of localization and delocalization with extremely large accelerations, it is necessary to use the eigenstate decomposition of systems in strongly non-equilibrium states – non-equilibrium CCSs;

self-consistent means based on the development of non-linear processes of all interconnected system components;

self-organization is the process of spontaneous ordering, formation, and evolution of structures in open non-linear systems;

self-harmonized means realized due to the self-consistent evolution of internal structure and system connections;

anisotropy of space and conservation laws – anisotropy is a change in the properties of space and the system depending on the direction; anisotropy corresponds to a violation of the conservation laws in the system;

negative viscosity is the property of the medium to provide positive feedback on external influences and contribute to the transformation of chaotic (thermal) movement of the medium into regular movement;

transformation of the energy of fluctuations into the energy of directed motion is a phenomenon similar to negative viscosity that occurs in a correlated coherent state;

blow-up mode is the process of explosive evolution of a system with positive feedback, in which higher-order accelerations (within the limit of all orders) are non-zero for the evolution of the parameters of the main system. i.e. this is the mode with positive feedback;

explosive blow-up mode of the self-harmonized electromagnetic confinement is the development of **electrostatic confinement** of plasma in a situation when a system of virtual electrodes that has appeared in the medium begins to move towards the center of the system with increasing acceleration in the **blow-up mode**. At the same time, the electrostatic structure becomes electrodynamic and evolves with positive feedback (with negative viscosity) to a **superdense state**;

coherent fusion is a method of controlled fusion in which the fusion process is controlled not only by thermodynamic parameters (density and temperature) but also/or by controlling the coherence of the target state due to the implementation of controlled non-stationarity of fuel states. Coherent fusion can be initiated together with **the explosive blow-up mode of the self-harmonized electromagnetic confinement**.

PRIOR ART

The fundamental problem of modern humanity is to ensure energy supply for its further development on a scale sufficient to meet its rapidly growing needs and without the risk of further detrimental effects on nature.

With the beginning of the 21st century, the use of fossil fuels for energy production is becoming increasingly unacceptable, primarily for environmental reasons, and nuclear energy is the only option and the basic source of energy generation in the future. This fact made the IAEA (International Atomic Energy Agency) formulate the following four basic requirements for the large-scale nuclear energy production in the future:

1. Unlimited reserves of raw materials for nuclear fuel production sufficient for hundreds of years;
2. Equivalence of the amount of radiation extracted from the Earth's interior and disposed of therein after burning isotopes of fissile nuclear materials;
3. Ensuring conditions that guarantee non-proliferation of nuclear weapons;
4. Environmental safety of nuclear fuel facilities.

With regard to point 4, it should be noted that the reactors available today cannot operate effectively under load at reduced capacities in a safe mode. Any implemented and currently being developed solutions to the energy problem still cannot meet all the above natural

requirements. For example, all known and currently being developed controlled nuclear fusion devices use reactions consisting of a very large number of interactions between a small number of nuclei (most often these are collisions and interactions of two nuclei). The number of such pairwise collisions must ensure an energy yield that is greater than the energy consumed to initiate the process. At the same time, the interaction of nuclei occurs in an ideal way – according to the laws of inertial frames of reference, and in this case, the collectivity of fusion is ensured by the quasi-equilibrium thermodynamics of the state of the system with many nuclei interacting in pairs. In this case, the control of reactions is very limited and occurs through the control of the probabilities of nuclear fusion processes by only three thermodynamic parameters of the system of nuclei – density, pressure, and temperature. Providing that, the proportion of nuclei that react is exponentially small relative to the ratio of the characteristic energy of nuclear processes to the temperature of the substance, but at the same time the entire system heats up thus the process requires the consumption of a rather large amount of energy and is inefficient. Effective control should use a relatively small amount of external energy and utilize the potential of the instability of the system and the internal energy of the system itself.

The claimed invention solves the above-mentioned global energy problem of creating an efficient energy source that meets all IAEA requirements by implementing a system and method for controlling the properties of nuclear processes.

More specifically, the system described in the patent solves the following main problems:

1) energy release during fusion;

2) conversion (utilization) of energy into other forms (e.g., into electrical energy)

3) neutralization of harmful substances, since the primary (harmful) material can be used during fusion which will lead to its transformation into other lighter chemical elements that do not harm the environment.

Specific technical solutions that are the prior art of the claimed invention are stated below.

The prior art **[1]** knows a solution based on increasing the density and temperature of plasma from the components of paired nuclear fusion reactions simultaneously while keeping the plasma in this high-temperature state for a sufficiently long period of time using magnetic fields, provided that the criterion for initiating fusion reactions (criterion for self-ignition of fusion reactions) is met. The start-up condition is to achieve the corresponding boundary parameters.

The disadvantage of this solution is that when using this method above reactions are characterized by the low efficiency of nuclear fuel use.

Also, the prior art **[2]** knows a solution based on inertial confinement of plasma. The most famous type of inertial fusion, which is being successfully developed now, is laser inertial

fusion, in which a state of energy efficiency of the process is achieved in practice, wherein the energy efficiency of the process is greater than 1 with respect to the energy delivered to the target, but not with respect to the total energy consumed.

The disadvantage of this solution is that energy fusion occurs only after the reaction ignites in the central region of the target and is effective only at the beginning of the plasma expansion. At the same time, a small part of the nuclear fuel is involved in the reaction during a rather short period of inertial confinement.

Also, a solution based on the principle of hydrodynamic compression is known from the prior art **[3]**. This solution has the same disadvantages as the inertial fusion described above.

The prior art **[4], [5], [6], [7], [8]** also knows the technical solution based on plasma confinement using electrostatic fields in it.

The disadvantage of this solution is the low density of plasma contained in the electrostatic well, and therefore, the small number of fuel nuclei involved in the fusion processes.

A common disadvantage of the technical solutions cited above is the lack of additional control and self-harmonization of the nuclear fusion process.

Also, the prior art **[9]** knows the technical solution by S. Adamenko which uses the pulse impact and self-focusing of an electron beam on the surface of the target to initiate fusion processes during the movement of the substance compression area from the surface layer deep into the target up to the area close to the center of symmetry of the target which also participates in the fusion process.

An important feature of this solution is the possibility of conducting truly collective reactions which differ from the above technical solutions by a much larger number of nuclei involved in the process. Moreover, the types of nuclei involved in the process can be practically any stable or unstable radioactive nuclei (with varying degrees of efficiency). This method in principle solves the problem of a sharp increase (compared to other methods) in the amount of substance involved in the fusion process and at the same time makes it possible to use almost any condensed substance as nuclear fuel by using the internal energy of the system itself to control the fusion. The additional major advantage of S. Adamenko's technical solution is the initiation of the process of adjusting the properties of nuclei (binding energy and mass defect of nuclei) during the fusion process.

The disadvantages of the method are the limited parameters for controlling fusion processes, and as a result, the absence of the possibility of operational control of the properties and stability of fuel nuclei involved in the fusion process.

There are known technical solutions to the problem of nuclear process control, i.e., control of properties and stability of nuclei using electromagnetic fields **[10]** and solutions for the

generation and delivery of the necessary electromagnetic fields in the target area.

The disadvantage of these technical solutions is that it is impossible to use them directly to control nuclear fusion processes due to low efficiency because there is no chance to use the set of parameters necessary to control the fusion.

The closest analog of the claimed technical solution is a method of impact compaction of substance, a device for the realization of the method, and a plasma electrode for the device described in the patent of Ukraine for invention No. UA71084C2 and the publication **[11]**. The subject matter of the above invention is technical solutions for controlling the internal structure and properties of a system of a large number of nuclei and the source of energy released as a result of nuclear fusion. That is, the release of binding energy at the nuclear level occurs as a result of electromagnetic control of reactions of restructuring the internal structure of a system of interacting nuclei, which leads to their transfer to specific states with reduced Coulomb barriers (correlated coherent states). The specified elements significantly distinguish our technology from conventional variants of the so-called controlled nuclear fusion, which mainly uses only three quasi-equilibrium control parameters: temperature, density, and time of confinement of the state with these parameters.

Persons skilled in the art know that the synthesis of chemical elements is constantly taking place in stars. Recent studies have shown that most heavy elements are synthesized in collapsing stars. In the conditions of planet Earth, these "stellar synthesis processes" have already been realized in artificial conditions. Thus, for the first time, the process of artificial synthesis of nuclei at implosion (collapse) of matter was applied in nuclear munitions developed in the twentieth century **[12]**. This type of fusion proceeding due to pycnonuclear processes or compression processes **[13]** is now applied in the so-called inertial fusion. The prior art **[14]** knows about some successes achieved by American scientists. The physical steps of the fusion process in this case were presented by Edward Teller **[14]**, one of the inventors of the implosion process and the design of the thermonuclear bomb. For the sake of clarity, he compared the inertial fusion with an internal combustion engine. In inertial fusion, in the implosion (inward explosion) mode, energy flows act on the surface of a passive piston causing it to move "towards the center". Under the action of the reactive force thus created, a high-density region (non-linear wave edge) moves towards the center and the target is compressed. The compression of the central part of the target ignites the nuclear fuel in the center of the target (initiates the first fusion reactions in the fuel located in the central region of the target). The central region of the target explodes and particles of its material fly away. At the same time, until the limit density and temperature are maintained, "nuclear combustion" takes place and energy continues to be released; this energy can be further removed from the target in the form of heat. In such

facilities, relativistic electron high-current beams, laser and X-ray radiation are used as drivers of the fusion process. Attempts to realize different kinds of inertial fusion are now taking place in different laboratories **[14,16,34]**.

The present invention describes a method of impact compaction of substance using a relativistic vacuum diode and a device (system) for its implementation, chosen as a prototype of this invention.

The prototype solves three problems:

1) the relative universality of fuel for the reactor;

2) the possibility of using nuclear fusion to generate energy in a wide range from the amounts required in everyday life to industrial scale;

3) the possibility of efficient use of fuel with a minimum amount of waste.

The disadvantages of the technical solution claimed in the prototype include:

1) the described control parameters: voltage pulse amplitude, the gap between cathode and anode and target size, which initiate inertial nuclear fusion in the target, do not allow for operational control of the characteristics of the blow-up mode in the target, since there are no parameters that can control the parameters of the current pulse during the voltage pulse and, accordingly, the possibility of initiating the collapse process in the target;

2) the described components of the electron beam for controlling nuclear fusion in the target do not allow controlling the initiation of the collapse process, since there are no physical means to change the parameters q_{VC} , a_P, and q_{EM};

3) the device (system) proposed in the prototype operates inefficiently and does not provide the ability to control the fusion process during the applied voltage pulse due to the following reasons**:**

a. the physical properties of the space around the electrodes do not meet the requirements for optimal initiation of collapse (blow-up mode) in the target, which does not allow to obtain the necessary energy released during fusion, or may even disrupt the fusion process;

b. there is no system of additional drivers and the ability to control the sequence of activation of high-voltage devices that are part of the drivers, which leads to the initiation of collapse (blow-up mode) with ineffective parameters q_{VC} , a_P , and q_{EM} or even to the failure of the initiation of the blow-up mode and, therefore, to the failure of the fusion process;

c. there is no system for controlling the electron beam dynamics in the diode to ensure a controlled focal space, which leads to a possible exit of the control parameters q_{VC} , a_P, from the optimal range of values and, accordingly, causes low efficiency of the entire process of coherent nuclear fusion;

d. the absence of matching lines (between the high voltage source and the diode: at the diode input and in the diode itself) worsens the control effects of the beam on the target and can bring the parameters q_{VC} , a_P, and q_{EM} out of the optimal range of values and disrupt the optimal fusion mode.

Thus, the incomplete set of variable parameters of the described device, the absence of some control elements in the device, and the use of not all necessary electromagnetic field components do not allow to:

1) control the processes of nuclear fusion evolution in the blow-up mode initiated in the near-surface layer of the anode target of the diode effectively;

2) achieve high energy released during the target explosion;

3) sufficiently increase the amount of fusion.

All of the above leads to the fact that energy production for industrial use cannot be solved within the prototype without its development.

The proposed technical solution is based on the improvement (modification) of the fusion facilities implemented so far, such as the one described in **[15]**, including by increasing the density of the target material in the process of initiation of self-consistent collapse of the said material.

An array of high-current electron accelerator modules located around the target is traditionally used to compress the target **[16]**. For example, this principle is implemented in the Angara multimodule electron inertial fusion facility **[34]**, which consists of eight electron accelerator modules located along the perimeter of the reaction chamber.

In the practical implementation of the technical solution by S. Adamenko **[15]**, selected as a prototype, it was possible to implement the implosion process in the target using only one module made as a cathode-anode unit of a high-current diode in the Proton-21 facilities. The use of the prototype allows to realize focusing of the electron beam on the target surface and initiation of the implosion process and explosion of the target in the process of which new elements are synthesized. The nuclear fusion of new elements in the facilities has been proved by studies of Proton-21 **[19]**, **[20]**. The prototype **[15]** has several disadvantages, which will be discussed below and which can be overcome by the claimed technical solution, that makes it possible to obtain explosion energy exceeding the energy delivered by the beam driver to the target.

The description of the application below specifies the features of the cathode-anode module to eliminate the disadvantages of the prototype and indicates the basic conditions necessary for the implementation of fusion processes.

BRIEF DESCRIPTION OF THE INVENTION

The aim of the claimed invention is to create a system that implements the following functionalities:

1) it is able to control the blow-up mode in the condensed substance of the target and the medium around the target by providing:

a. control of the size and thickness of the initial compression area of the target substance, and the spread of the compression area on the wave edge from the periphery of the target to its central part;

b. controlled realization of fusion processes in the area of substance density sufficient for these processes and release of fusion energy as the wave edge advances to the center of the target;

c. controlled accumulation of the released nuclear energy of the target which occurs during the movement of the area of increasing substance density and during the explosion in the central part of the target.

2) it has multicomponent plasma electrodes of a special shape (that ensure effective beam focusing) which allow to increase the current in the plasma diode significantly;

3) it allows to control the medium around the electrodes that ensures a high value of the beam volumetric charge parameter q_{VC} over a sufficiently long time interval, during a voltage pulse applied to the diode electrodes using electromagnetic sources and/or laser radiation sources;

4) it uses plasma formations with a certain heterogeneity and non-stationarity in the focusing zone of the electron beam, which provides an impact q_P sufficient to change the energy direction of the processes, where high-voltage discharge plasma, plasma guns, and/or laser sources are used for their implementation;

5) it contains sources of electromagnetic fields with a specific toroidal topology and a high proportion of radial components (q_{EM}) to control the value of the Coulomb barrier and internal structure of atoms and nuclei of the reactor target fuel;

6) it has devices for converting the kinetic energy of fusion products and electromagnetic radiation in a wide range of energies generated in the fusion processes into electrical energy that can be used further or stored in energy storage devices.

DESCRIPTION OF FIGURES

Fig. 1 shows a general block diagram of the proposed system.

Fig. 2 shows a block diagram of the main physical areas of the reaction chamber.

Fig. 3 shows characteristic types of a voltage pulse in the gap between cathode and anode, current in the gap between cathode and anode and in the space behind the anode.

Fig. 4 shows a block diagram of additional fusion driver No. 1.

Fig. 5 shows a block diagram of additional fusion driver No. 2.

Fig. 6 shows a block diagram of additional fusion driver No. 3.

Fig. 7 shows a block diagram of converting the kinetic energy of the explosion products into electrical energy accumulated in the system of energy storage devices.

Fig. 8 shows a block diagram of converting the energy of the current and electromagnetic fields that have passed the explosion area into electrical energy accumulated in the system of energy storage devices.

Fig. 9 shows a block diagram of converting the radiation energy and explosion plasma into electrical and thermal energy.

Fig. 10 shows a block diagram of converting the energy of the electromagnetic fields after the target explosion into electrical energy accumulated in the system of energy storage devices.

Fig. 11 shows the structure of the non-linear wave edge (shell) with central symmetry (spherical, cylindrical, elliptical, and their combinations) in the target during the initiation of coherent fusion.

Fig. 12 shows our experimental data of the light intensity recorded by the monochromator at three points as a function of time and the calculation of the velocity of the target explosion products based on the time spent to travel the distance between the corresponding points.

Fig. 13.1 shows the dynamics of the decimal logarithm of the shell density as a function of the fraction of the distance traveled to the collapse point according to the collapse ratios when implosion is developing in the active blow-up mode.

Fig. 13.2 shows the dependence of the decimal logarithm of the ratio of the shell density to the initial target density on the charge number of the nuclides, for which nuclides with a given charge number are optimal ratios known to persons skilled in nuclear astrophysics.

Fig. 14 shows the equivalent electrical circuit diagram of a device that converts kinetic energy flows at the input into a current and voltage pulse at the output. In this figure, L_0, R_0 are the effective electrical parameters of the energy flow, L_1, C_1, R_1 are the electrical parameters of the first circuit of the device, L_2, C_2, R_2 are the electrical parameters of the second circuit of the device described in **[30]**.

The attached figures are marked with the following reference numbers:

1.0 – industrial electrical network module;

1.1 – charging module of the primary energy storage device;

1.2 – primary energy storage device;

1.3 – control module for the primary energy storage device (1.2) for units (1.4, 1.5, 1.6, 1.7), where the module (1.11) is designed for the preparation of the reaction chamber (1.8) and the module (1.10) is designed for the supply of targets (1.10.1);

1.4 – module of main fusion driver No. 4 [*which delivers energy to the target*];

1.4.1 – unit for synchronizing the primary energy storage device (1.2) and generating energy flows of fusion driver No. 4;

1.4.2 – unit for coordinating energy flows of fusion driver No. 4 and the target (1.10.1);

1.5 – module of additional fusion driver No. 3 [*which controls the initiation of a non-linear wave in the target and modifies properties of the target substance*];

1.5.1 – unit for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 3;

1.5.2 – unit for generating energy flows of fusion driver No. 3;

1.6 – module of additional fusion driver No. 2 *[which controls the initiation of the explosive blow-up mode]*;

1.6.1 – unit for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 2;

1.6.2 – unit for generating energy flows of fusion driver No. 2;

1.7 – module of additional fusion driver No. 1 for controlling plasma electrodes;

1.7.1 – unit for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 1;

1.7.2 – unit for generating energy flows of fusion driver No. 1;

1.8 – reaction chamber;

1.9 – module for taking the kinetic energy flow (1.12) of fusion products and high-level radiation energy from the target explosion area (2.16);

1.10 – module for the sequential supply of targets;

1.10.1 – target;

1.11 – module for the preparation of the reaction chamber (1.8);

1.12 – kinetic energy flow of fusion products and high-level radiation energy from the target explosion area;

1.13 – grounded reverse current conductor;

1.14 – module for converting the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16);

1.14.1 – unit for taking kinetic energy of fusion products;

1.14.2 – unit for coordinating converted energy with the unit of output energy storage

devices No. 1 (1.17);

1.15 – module for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16);

1.15.1 – unit for taking electromagnetic radiation energy from the target explosion area (2.16);

1.15.2 – a unit for coordinating converted energy with output energy storage device No. 1 (1.17);

1.16 – module for converting the energy flow (1.20) in the reverse current area in the grounded reverse current conductor (1.13);

1.16.1 – unit for taking the energy of currents of the grounded reverse current conductor (1.13);

1.16.2 – unit for coordinating the converted energy with output energy storage device No. 2 (1.18);

1.17 – output energy storage device No. 1;

1.18 – output energy storage device No. 2;

1.19 – module for coordinating the unit of output energy storage devices No. 2 (1.18) with the primary energy storage device (1.2);

1.20 – energy flow in the reverse current area;

1.21 – output energy flow;

1.22 – kinetic energy flow of fusion products from the target explosion area (2.16);

1.23 – current and electromagnetic fields energy flow from the target explosion area (2.16);

2.1 – plasma guns of fusion driver No. 1;

2.2 – electromagnetic field generators of fusion driver No. 1;

2.3 – plasma guns of fusion driver No. 2;

2.4 – toroidal electromagnetic field generators of fusion driver No. 2;

2.5 – radial current field generator of fusion driver No. 3;

2.6 – plasma generated by fusion driver No. 1;

2.7 – multicomponent cathode plasma module;

2.8 – cathode plasma;

2.9 – anode plasma structures module;

2.10 – anode plasma;

2.11 – unit of coils of a special structure of the module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16) to excite voltage and current pulses in their elements initiated by the kinetic energy flow of explosion products of the target (1.10.1);

2.12 – housing of the reaction chamber (1.8);

2.13 – module for taking the flow of high-level radiation energy from the target explosion area (2.16) with a blanket for absorbing high-level radiation and taking thermal energy;

2.14 – gap between cathode and anode plasma;

2.15 – module for taking the current energy flow that passed the target explosion area (2.16) and the anode plasma structures module (2.9);

2.16 – target explosion area;

3.0 – preliminary voltage pulse against which a high-voltage pulse (3.1) is generated;

3.1 – high-voltage pulse where the characteristic shape of the pulse is set by the following parameters:

t_0 – delay of the high-voltage pulse relative to the moment of the start of pulse generation;

U_0 – voltage amplitude of the previous pulse;

t_p – duration of the high-voltage pulse;

t_f – duration of the leading edge of the pulse;

t_b – duration of the trailing edge of the pulse;

t_{max} – the moment of reaching the maximum of the pulse;

U_p – the amplitude of the high-voltage pulse;

3.2 – current pulse in the gap between cathode and anode;

3.3 – current pulse in the space behind the anode after passing the anode plasma area and the target explosion area;

4.1 – module for synchronizing the pulse equipment of fusion driver No. 1 with the signal from the module (1.3);

4.2 – source of pulsed current and voltage of fusion driver No. 1;

4.3 – module for setting the signal offset of fusion driver No. 1;

4.4 – plasma gun for focusing the electron beam of fusion driver No. 1;

4.5 – module for generating pulsed electromagnetic radiation and/or laser radiation to control the initiation of emission processes by the cathode unit of fusion driver No. 1;

5.1 – module for synchronizing the pulse equipment of fusion driver No. 2 with the signal from the module (1.3);

5.2 – source of pulsed current and voltage of fusion driver No. 2;

5.3 – module for setting the signal offset of fusion driver No. 2;

5.4 – plasma gun for focusing the electron beam of fusion driver No. 2;

5.5 – module for generating pulsed electromagnetic radiation and/or laser radiation of fusion driver No.2 to control the shape of the beam current and the processes for generating the blow-up mode in the target (1.10.1)

6.1 – module for synchronizing the pulse equipment of fusion driver No. 3 with the signal from the module (1.3)

6.2 – source of pulsed current and voltage of fusion driver No. 3;

6.3 – module for setting the signal offset of fusion driver No. 3;

6.4 – module of fusion driver No. 3 for generating radial currents to focus and/or self-focus the electron beam on the target surface (1.10.1);

6.5 – module of fusion driver No. 3 for generating pulsed electromagnetic radiation with longitudinal polarization to control the blow-up mode in the target (1.10.1) and the properties of the target materials in the target explosion area.

7.1 – module's condensed working medium made of the ferroelectric and/or ferromagnetic material and/or a finely dispersed mixture of dielectric and conductive components;

7.2 – unit for taking the energy flow of voltage and current pulses initiated in the condensed working medium (7.1) by the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16);

7.3 – module for coordinating the output energy flow of the unit (7.2) with the unit of output energy storage devices No. 1 (1.17);

8.1 – unit for taking the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16);

8.2 – transmission line for transmitting the target explosion energy taken in the unit (8.1) to the module (8.3) for transforming and coordinating the flows of the taken energy with the unit of output energy storage devices No. 1 (1.17);

8.3 – module for transforming and coordinating the flows of the taken energy with the unit of output energy storage devices No. 1 (1.17);

9.1 – module for converting the energy released in the module blanket (2.13) into electrical and/or thermal energy;

9.2 – electrical energy storage unit;

9.3 – thermal energy storage unit;

10.1 – unit for taking the energy flow (1.20) of currents in the grounded reverse current conductor (1.13);

10.2 – transmission line for transmitting the energy taken in the unit (10.1) to the module (10.3) for transforming and coordinating the flow of the taken energy and the unit of output energy storage devices No. 2 (1.18);

10.3 – module for transforming and coordinating the flow of the taken energy and the unit of output energy storage devices No. 2 (1.18);

11.1 – target's inner central part (fusion fuel);

11.2 – non-linear wave edge structure (shell) with the center of symmetry and internal structure in the correlated coherent state;

11.3 – leading edge structure of a non-linear wave with the center of symmetry in the target;

11.4 – main "body" of the non-linear wave edge (shell) with the center of symmetry;

11.5 – trailing edge structure of a non-linear wave with the center of symmetry;

11.6 – region of fusion products evaporating from the trailing edge of the non-linear wave;

11.7 – target surface boundary with the center of symmetry;

11.8 – center of symmetry of the non-linear wave edge (shell) in the target;

12.1 – measured intensity of the optical signal of the particle flow as a function of time at point 1 with a distance of 0.9 cm from point 2 traveled in 0.379 *microseconds* and a distance of 1.8 cm from point 3 traveled in 0.750 *microseconds*;

12.2 – measured intensity of the optical signal of the particle flow as a function of time at point 2 with a distance of 0.9 cm from point 3 traveled in 0.371 *microseconds*;

12.3 – measured intensity of the optical signal of the particle flow as a function of time at point 3.

In this experiment, the particle flow velocities estimated using these data is as follows:

$u_{1-2} = 0.9\ cm / 0.379\ microseconds = 2.38 * 10^6 cm/s;$

$u_{1-3} = 1.8\ cm / 0.750\ microseconds = 2.40*10^6\ cm/s;$

$u_{2-3} = 0.9\ cm / 0.371\ microseconds = 2.42*10^6\ cm/s.$

Note: Because of many modules, in each Figure we tried to use the “second level” of labeling, for example: (2.1) and (4.4) are the same plasma guns for driver No.1; (2.2) and (4.5) are the same electromagnetic field generators for driver No. 1.

DETAILED DESCRIPTION OF THE INVENTION

The claimed control system for nuclear processes and coherent nuclear fusion during the explosive blow-up mode of the self-harmonized electromagnetic confinement comprises the following components: an industrial electrical network module (1.0); a charging module (1.1) of the primary energy storage device; a primary energy storage device (1.2); main fusion driver No. 4 with a module (1.4). Module (1.4) is designed to provide the transfer of the main part of the control energy from the primary source to the target required to initiate the fusion process in the target in the blow-up mode.

For example, the main elements of driver No.4 in the diode are:

a) a high voltage pulse between the plasma systems of the cathode and anode (a typical voltage waveform measured at the cathode is shown in Fig. 3.1);

b) a current pulse from the plasma cathode system in the diode interelectrode space caused

by the high voltage pulse (a typical current waveform measured at the cathode is shown in Fig. 3.2);

c) a current pulse inside the anode-target system caused by a high-voltage pulse (a typical current waveform measured behind the anode is shown in Fig. 3.3.).

While the module (1.4) comprises a unit (1.4.1) for synchronizing the primary energy storage device (1.2) and generating energy flows of fusion driver No. 4; a reaction chamber (1.8); a grounded reverse current conductor (1.13); a target (1.10.1). The mentioned primary energy storage device (1.2) is known to those skilled in the art and consists of also rather well-known electrophysical devices (high-voltage pulse capacitors and dischargers) described in **[26]**, **[28]**. As for the design of module (1.4), it is also known from the prototype **[15]**.

Whereas, according to the claimed invention, the said system further comprises: a module (1.10) for the sequential supply of targets (1.10.1) to the reaction chamber (1.8); a module (1.11) for the preparation of the reaction chamber (1.8); additional fusion driver No. 1 with a module (1.7) for controlling plasma electrodes, while the module (1.7) comprises a unit (1.7.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 1 and a unit (1.7.2) for generating energy flows of fusion driver No. 1; additional fusion driver No. 2 with a module (1.6) to control the initiation of the explosive blow-up mode, while the module (1.6) comprises: unit (1.6.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 2 and a unit (1.6.2) for generating energy flows of fusion driver No. 2; additional fusion driver No. 3 with a module (1.5) to control the initiation of a non-linear wave in the target and modify properties of the target substance, while the module (1.5) comprises: unit (1.5.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 3 and a unit (1.5.2) for generating energy flows of fusion driver No. 3. Whereas, under the condition of optimal synchronization of units 1.4.1, 1.5.1, 1.6.1, and 1.7.1, additional fusion driver No. 3 also controls the process of initiating a non-linear wave with an edge (11. 2), which contains the leading-edge structure (11.3) of the non-linear wave, the main "body" (11.4) of the non-linear wave edge, and the trailing edge structure (11.5) of the non-linear wave and moves from the target surface (11.7) to its center of symmetry (11.8). Whereas, the wave with the leading edge (11.3) moves in such a way that the target's inner central part (fusion fuel) (11.1) is in front of it, and the region (11.6) of fusion products evaporating from the trailing edge of the non-linear wave is behind it. Whereas, the module (1.4) for delivering energy to the target further comprises a unit (1.4.2) for coordinating the energy flows of fusion driver No. 4 and the target (1.10.1); output energy storage device No. 1 (1.17); output energy storage device No. 2 (1.18);

a module (1.3) for controlling a primary energy storage device (1.2), a unit (1.4.1) for synchronizing the primary energy storage device (1.2) and generating energy flows of fusion driver No. 4; a unit (1.4.2) for coordinating energy flows of fusion driver No. 4 and the target (1.10.1); a unit (1.5.1) for coordinating and synchronizing energy of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 3; a unit (1.5.2) for generating energy flows of fusion driver No. 3; a unit (1.6.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 2; a unit (1.6.2) for generating energy flows of the fusion driver No. 2; a unit (1.7.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 1; a unit (1.7.2) for generating energy flows of fusion driver No. 1; a module (1.11) for the preparation of the reaction chamber (1.8) and a module (1.10) for the sequential supply of targets (1.10.1).

Whereas, the transmission lines and the inhomogeneous plasma formed in them known from the prior art **[26], [28], [35]** are used as the unit (1.4.2) for coordinating energy flows. The module (1.11) for the preparation of the reaction chamber (1.8) consists of a set of pumps capable of creating a sufficient vacuum (about 10^{-5} mm Hg) in the chamber. This is a typical unit for preparing the reaction chamber by creating the necessary pressure in the chamber (about 10^{-5} mm Hg) which is well-known for the persons skilled in the art.

Whereas, the module (1.14) for converting the kinetic energy flow of fusion products from the target explosion area (2.16), in turn, comprises a unit (1.14.1) for taking kinetic energy of fusion products and a unit (1.14.2) for coordinating converted energy with the unit of output energy storage devices No. 1 (1.17). The module (1.14) for converting the kinetic energy is based on known solutions published in the prior art **[30], [31], [32].** In the mentioned technical solutions, the energy of the explosion in the form of kinetic energy of particles is converted into electric current pulses. This conversion occurs as a result of the appearance, due to the flows of the explosion products, of non-stationary inductance and/or non-stationary capacitance (circuits with active elements) in coupled electrical circuits with parametric instabilities (see Fig. 14), such as those described in **[37], [38]** and in special highly polarized environments in devices, such as those described in **[30], [31], [32]**.

Whereas, the module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16), in turn, comprises a unit (1.15.1) for taking electromagnetic radiation energy from the target explosion area and a unit (1.15.2) for coordinating the converted energy with the unit of output energy storage devices No. 1 (1.17). Whereas, the module (1.16) for converting the energy flow (1.20) in the reverse current area in the grounded reverse current conductor (1.13) in turn comprises a unit (1.16.1) for taking the

energy of currents of the grounded reverse current conductor (1.13) and a unit (1.16.2) for coordinating the converted energy with the unit of output energy storage devices No. 2 (1.18). The claimed system also comprises a module (1.19) for coordinating the unit of output energy storage devices No. 2 (1.18) with the primary energy storage device (1.2).

The design of drivers No. 1, No. 2, and No. 3 is based on devices and circuits for generating electromagnetic fields known from the prior art.

Thus, plasma guns described in the prior art **[28]**, injecting low energy plasma into the target region and/or laser radiation source for ionization of the electrode surface layer described in the prior art **[26]**, **[28]**, and/or toroidal coils described in **[27]**, and other physical effects (for example, discharge on the electrode surface from an applied high voltage) can be used for the system of fusion drivers No. 1, which is designed to prepare the medium around the target for the primary ionization of the target surface layer.

The system of drivers No. 2 is designed to initiate a blow-up mode in the medium around the target and the target itself for the primary ionization of the surface layers of the condensed matter. Plasma guns injecting plasma of light elements with sufficiently high temperature into the target region described in the prior art **[28]** and/or a source of laser radiation for ionization of the surface layer of electrodes described in **[26], [28]**, or toroidal coils of the design described in **[27]**, and other devices can be used as a driver. Whereas, if a plasma diode is used as driver No. 2, the system for coordinating the energy flows of the primary energy storage device and the energy of the system of drivers No. 2 may be implemented in the form of input and output circuit breakers described in **[26]**, pulse transformers of the design described in **[26], [28]** and/or forming and transmitting coaxial and strip lines described in **[35]**, **[26], [28]**, etc.

The system of drivers No. 3 is designed to control the fusion processes at the initial stage of the blow-up mode. The following devices can be used as drivers in the diode: a system of special coils generating electromagnetic fields with longitudinal polarization, for example, described in **[36]**; systems of radial pulse currents, for example, described in **[29]**; control system of radial currents of self-focusing electron beam, for example, described in **[15]**, etc.

Whereas, according to the claimed invention, the reaction chamber (1.8) comprises the following components: the plasma guns (2.1) of fusion driver No. 1, preferably arranged with central symmetry around the axis of the reaction chamber and designed to generate plasma (2.6) of the reaction chamber; the electromagnetic field generators (2.2) of fusion driver No. 1, preferably arranged with central symmetry around the axis of the reaction chamber; the plasma guns (2. 3) of fusion driver No. 2, preferably arranged with central symmetry around the axis of the reaction chamber; the electromagnetic field generators (2.4) of fusion driver No. 2, preferably arranged with central symmetry around the axis of the reaction chamber; the radial

current field generators (2.5) of fusion driver No. 3, preferably arranged with central symmetry around the axis of the reaction chamber; a multicomponent cathode plasma module (2.7) designed to generate a cathode plasma flow (2.8); anode plasma structures module (2.9) designed to generate anode plasma flow (2.10); a unit (2.11) of coils of a special structure of the module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16) to excite voltage and current pulses in their elements initiated by the kinetic energy flow of explosion products of the target (1.10.1); a housing (2.12) of the reaction chamber (1.8); a target explosion area (2.16); a module (2.13) for taking the flow of high-level radiation energy from the target explosion area (2.16) with a blanket for absorbing high-level radiation and taking thermal energy; a gap (2. 14) between the cathode and anode plasma flows; a module (2.15) for taking the current energy flow that passed the target explosion area (2.16) and the anode plasma structures module (2.9).

Whereas, according to the claimed invention, fusion driver No. 1 comprises the following components: a module for synchronizing the pulse equipment with the signal from the module (1.3); a source (4.2) of pulsed current and voltage; a module (4.3) for setting the signal offset; the plasma guns (4. 4) for focusing the electron beam; a module (4.5) for generating pulsed electromagnetic radiation and/or laser radiation to control the initiation of emission processes by the cathode unit of fusion driver's No. 1.

Whereas, according to the claimed invention, fusion driver No. 2 comprises the following components: a module (5.1) for synchronizing the pulse equipment with the signal from the module (1.3); a source (5.2) of pulsed current and voltage; a module (5.3) for setting the signal offset; a plasma gun (5.4) for focusing the electron beam of fusion driver No. 2; a module (5.5) for generating pulsed electromagnetic radiation and/or laser radiation to control the shape of the beam current and the processes for generating the blow-up mode in the target (1.10.1).

Whereas, according to the claimed invention, fusion driver No. 3 comprises the following components: a module (6.1) for synchronizing the pulse equipment with the signal from the module (1.3); a source (6.2) of pulsed current and voltage; a module (6.3) for setting the signal offset; a module (6.4) for generating radial currents to focus and/or self-focus the electron beam on the target surface (1.10.1); and/or a module (6.5) for generating pulsed electromagnetic radiation with longitudinal polarization to control the blow-up mode in the target (1.10.1).

Whereas, according to the claimed invention, the module (1.14) for converting the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16) further comprises the following components: a module's condensed working medium (7.1) made of the ferroelectric and/or ferromagnetic material and/or a finely dispersed mixture of dielectric and conductive components; a unit (7.2) for taking the energy flow of voltage and current pulses

initiated in the condensed working medium (7.1) by the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16); a module (7.3) for coordinating the output energy flow of the unit (7.2) with the unit of output energy storage devices No. 1 (1.17); the unit of output energy storage devices No. 1 (1.17)

Whereas, according to the claimed invention, the module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16) further comprises the following components: a unit (8.1) for taking the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16); a transmission line (8.2) for transmitting the target explosion energy taken in the unit (8.1) to the module (8.3) for transforming and coordinating the flows of the taken energy with the unit of output energy storage devices No. 1 (1.17); a module (8.3) for transforming and coordinating the flows of the taken energy with the unit of output energy storage devices No. 1 (1.17);

Whereas, according to the claimed invention, the module (1.9) for taking the kinetic energy flow (1.12) of fusion products and high-level radiation energy from the target explosion area (2.16) further comprises the following components: a unit (9.1) for converting the energy released in the module blanket (2.13) into electrical and/or thermal energy; an electrical energy storage unit (9.2); a thermal energy storage unit (9.3).

Four qualitatively different energy flows emerge from the target explosion area. Among them are the kinetic energy flow (1.12) of fusion products (particle flow) and the kinetic energy flow (1.22) of high-level radiation (includes alpha, beta, X-ray and gamma rays). All of these flows differ in the nature of their interaction with the surrounding matter and they lose their energy in module (1.9) in different media with magnetic and/or electric polarization. The indicated interactions of high-energy flows of particles and quanta of the electromagnetic field are well known to the persons skilled in the art, for example, from the prior art source **[33]**.

Whereas, according to the claimed invention, the reaction chamber (1.8) further comprises a multicomponent cathode plasma module (2.7) and an anode plasma structures module (2.9).

Whereas, according to the claimed invention, unsteady plasma electrical and electromagnetic structures are placed additionally in the focusing zone of the electron beam, providing an impact sufficient to change the energy direction of the processes, while electromagnetic sources and high-voltage discharge plasma generated by plasma guns and/or laser sources are used to control their implementation.

Whereas, according to the claimed invention, in the reaction chamber (1.8), the system further comprises toroidal electromagnetic field generators (2.4) of fusion driver No. 2 and the radial current field generators (2.5) of fusion driver No. 3 to control the value of the Coulomb barrier and the internal structure of the fuel nuclei of reactor target (1.10.1).

Whereas, according to the claimed invention, the reaction chamber (1.8) further comprises a module (1.14) for converting the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16); a module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16); a module (1.16) for converting the energy flow (1.20) in the reverse current area in the grounded reverse current conductor (1.13). Also, four qualitatively different energy flows emerge from the target explosion area, namely, the current and electromagnetic fields energy flow (1.23) (light, microwave radiation, and the energy flow of quasi-stationary electromagnetic fields) and the flow (1.20) of thermal energy (includes infrared radiation). These flows differ in their interaction with matter and lose their energy in different media with magnetic and/or electric polarization in the module (1.9). The indicated interactions of high-energy flows of particles and quanta of the electromagnetic field are well known to the persons skilled in the art, for example, from the prior art source **[33]**. Whereas, according to the claimed invention, the system comprises more than one additional fusion driver No. 1 and/or additional fusion driver No. 2 and/or additional fusion driver No. 3.

The inventor also proposes a method for controlling nuclear processes and coherent nuclear fusion during the explosive blow-up mode of the self-harmonized electromagnetic confinement using the above system. The method according to the claimed invention includes the following steps. With the charging module (1.1) of the primary energy storage device, the energy supplied from the industrial electrical network module (1.0) is accumulated in the primary energy storage device (1.2). With the module (1.3), the primary energy storage device (1.2), units (1.4.1, 1.4.2, 1.5.1, 1.5.2, 1.6.1, 1.6.2, 1.7.1, 1.7.2) of fusion drivers, the module (1.11) for the preparation of the reaction chamber (1.8), and the module (1.10) for the supply of targets (1.10.1) are controlled. With the module (1.10), a sequential supply of targets (1.10.1) into the reaction chamber (1.8) with a specified repetition rate is implemented. With the module (1.11), the reaction chamber (1.8) is prepared. With the unit (1.7.1), the energy flows of the primary energy storage device (1.2) and the energy flows of additional fusion driver No. 1 are coordinated and synchronized. With additional fusion driver No. 1, the medium around the target (1.10.1) is prepared in the reaction chamber (1.8) to ensure primary ionization of the target surface layer. With the unit (1.4.1), the energy flows of the primary energy storage device (1.2) and the energy flows of main fusion driver No. 4 are generated and synchronized. With the unit (1.6.1), the energy flows of the primary energy storage device (1.2) and the energy flows of additional fusion driver No. 1 are coordinated and synchronized. With additional fusion driver No. 2 and the unit (1.4.2) of fusion driver No. 4, the power profile of the energy flow from main fusion driver No. 4 is formed according to the time. With additional fusion driver No. 2 and the unit (1.3), the moment of initiation of the blow-up mode is controlled and energy is accumulated in

the surface layer of the target to initiate a non-linear wave. With additional fusion driver No. 2, the blow-up mode is initiated in the reaction chamber's (1.8) medium around the target (1.10.1) and in the target itself to ensure the primary ionization of the surface layers of the condensed matter. With the unit (1.5.1), the energy flows of the primary energy storage device (1.2) and the energy flows of additional fusion driver No. 3 are coordinated and synchronized. With additional fusion driver No. 3, the properties of target materials and fusion processes are controlled at the initial stage of the blow-up mode. With additional fusion driver No. 3 and additional fusion driver No. 2, the following processes are controlled: initiation of the beginning of the edge (11.2) movement of the non-linear wave in the correlated coherent state with the center of symmetry (11.8) and the internal structure of the leading edge structure (11.3) moving from the surface (11.7) to the center of symmetry (11.8) of the target; the state of the main "body" (11.4) of the non-linear wave edge, the structure of the trailing edge structure (11.5) of the non-linear wave. Whereas, the target's inner central part (fusion fuel) (11.1) is located in front of the non-linear wave, while the region (11.6) of fusion products evaporating from the trailing edge of the non-linear wave is located behind it. With the module (1.14), the kinetic energy of fusion products is converted into electrical energy. With the module (1.14.2), the converted energy is coordinated with the unit of output energy storage devices No. 1 (1.17). With the module (1.15), the flow of kinetic energy of the fusion products from the target explosion area is converted into electrical energy. With the unit (1.15.2), the flow of converted energy is coordinated with the unit of output energy storage devices No. 1 (1.17) and the received energy is accumulated in output energy storage device No. 1 (1.17). With the module (1.9), the flow of kinetic energy of the fusion products from the target explosion area (2.16) is converted into electrical energy and/or thermal energy. With the unit (1.16.1), the energy flow (1.20) of currents of the grounded reverse current conductor (1.13) is taken. With the unit (1.16.2), the taken energy is coordinated with output energy storage device No. 2 (1.18). With the module (1.19), the unit of output energy storage devices No. 2 (1.18) is coordinated with the primary energy storage device (1.2), and the kinetic energy of the fusion products and the energy of electromagnetic radiation are taken.

Whereas, according to the claimed invention, the claimed method further includes the following steps. With the module (4.1), the signals of the pulse equipment of fusion driver No. 1 are synchronized with the module (1.3). With the source (4.2), a pulse current and voltage are generated. With the module (4.3), the offset of the signals of fusion driver No. 1 is initiated. With the plasma gun (4.4), the electron beam of fusion driver No. 4 is focused. With the module (4.5), pulsed electromagnetic radiation and/or laser radiation are generated to control the initiation of emission processes by the cathode unit of fusion driver no. 4.

Whereas, according to the claimed invention, the claimed method further includes the following steps. With the module (5.1), the signals of the pulse equipment of fusion driver No. 2 are synchronized. With the source (5.2), the pulse current and voltage of fusion driver No. 2 are generated. With the module (5.3), the offset of signals of fusion driver No. 2 is initiated. With the plasma gun (5.4), the electron beam of fusion driver No. 4 is focused. With the module (5.5), pulsed electromagnetic radiation and/or laser radiation of fusion driver No.2 are generated to control the shape of the beam current and the processes for generating the blow-up mode in the target (1.10.1).

Whereas, according to the claimed invention, the claimed method further includes the following steps. With the module (6.1), the signals of the pulse equipment of fusion driver No. 3 are synchronized with the signal of the module (1.3). With the source (6.2), the pulse current and voltage of fusion driver No. 3 are generated. With the module (6.3), the offset of the signals of fusion driver No. 3 is initiated. With module (6.4), radial currents of the electron beam that self-focuses on the target surface (1.14) are generated, and/or with the module (6.5), pulsed electromagnetic radiation with longitudinal polarization is generated to control the blow-up mode in the target (1.10.1) and the properties of the target materials in the target explosion area.

Whereas, according to the claimed invention, the kinetic energy of the target explosion is converted into electrical energy accumulated in the system of output energy storage devices No.1 (1.17). Whereas, with the impact of explosion products flow (1.22) of the target (1.10.1) in the condensed working medium (7.1) made of the ferroelectric and/or ferromagnetic material and/or a finely dispersed mixture of dielectric and conductive components, a polarization wave propagating through the medium is initiated; with the unit (7.2) for taking the energy flow of voltage and current pulses initiated in the condensed working medium (7.1) by the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16), voltage and current pulses initiated by a polarization wave in the working medium (7.1) are excited; with the module (7.3), the output energy flow of the unit (7.2) is coordinated with the unit of output energy storage devices No. 1 (1.17); with the unit of output energy storage devices No. 1 (1.17), the received electrical energy is accumulated.

Whereas, according to the claimed invention, the energy of the current and electromagnetic fields that have passed through the explosion area is converted into electrical energy accumulated in the system of energy storage devices No.1 (1.17). Whereas, with the unit (8.1) for taking the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16), the energy flow that has passed the target explosion area (2.16) and the transmission lines is coordinated; with the transmission line (8.2), the flow of the taken target explosion energy is transmitted to the module (8.3) for coordinating and transforming the pulse power; in

the module (8.3), the pulse power is coordinated and transformed from relatively high values after the explosion of the target (1.10.1) to the power values necessary for efficient energy storage in the unit of output energy storage devices No. 1 (1.17).

Whereas, according to the claimed invention, the energy of the radiation and explosion plasma is converted into electrical and thermal energy. Whereas, with the module (2.13) and the unit (9.1), the energy flows (1.12) of high-level radiation and fusion products resulting from the fusion processes in the target explosion area (2.16) are converted into thermal and/or electrical energy; electrical energy is accumulated in the unit (9.2); thermal energy is accumulated in the unit (9.3).

Whereas, according to the claimed invention, the energy of the current and electromagnetic fields that have passed through the explosion area and the reverse current conductor is converted into electrical energy accumulated in the system of output energy storage devices No. 2 (1.18). Whereas, with the unit (10.1) the energy flow (1.20) of the currents of the grounded reverse current conductor (1.13) is taken; the flow of the taken target explosion energy is transmitted via the line (10.2) to the module (10.3) for transforming and coordinating the pulse power; in the module (10.3), the pulse power is coordinated and transformed from relatively high values after the explosion of the target (1.10.1) to the power values necessary for efficient energy storage in the unit of output energy storage devices No. 2 (1.18).

Whereas, according to the claimed invention, the process is implemented using heterogeneous and non-stationary high-voltage discharge plasma structures (2.6, 2.8, 2.10) generated in the focusing zone of the electron beam using plasma guns and/or laser sources, which provides an impact sufficient to change the energy direction of the processes.

Whereas, according to the claimed invention, to implement the process, the value of the Coulomb barrier and the internal structure of the fuel nuclei of the reactor target (1.10.1) are controlled by toroidal electromagnetic field generators (2.4) and radial current field generators (2.5).

Whereas, according to the claimed invention, more than one additional fusion driver No. 1 and/or additional fusion driver No. 2 and/or additional fusion driver No. 3 are used to implement the process.

Whereas, according to the claimed invention, to implement the process, the kinetic energy of the fusion products and the electromagnetic radiation due to the fusion processes in a wide range of energies is converted into electrical energy which can be used for other purposes or accumulated in energy storage devices.

EXAMPLE OF THE INVENTION IMPLEMENTATION

The experiments with the device designed to optimize the implementation of the technology of controlled electromagnetic coherent nuclear fusion in targets and the release of matter binding energy continued a large long-term series of experiments that proved the possibility of realizing pycnonuclear fusion in relatively small laboratory devices constructed pursuant to patent UA71084C2. Numerous experiments were conducted on the new generation devices (with a high-voltage pulse amplitude of about 10^6 V and electron beam currents in the range of hundreds of kA based on the double-Blumlein line (DBL)). These experiments demonstrated the energy output exceeding the amount of energy delivered to the target (Q_{Tag} >1) and the amount of energy consumed from the network (Q_W >1).

The proposed invention sets forth driver embodiments leading to the realization of implosion and to the fusion of nuclei during the target explosion. When the conditions for driver No. 4 are met in matching the parameters of the target and the parameters of driver No. 4, as set forth on pp. 4, 34, 39 of said description, a non-linear wave with the edge structure shown in Fig. 11 is initiated in the target. Such a wave initiates the explosion of the central part of the target and the release of energy which exceeds the energy delivered to the target. This fact is supported by optical and thermal measurements (see Table 3 and source [30]). According to the proposed method, due to the impact of an electron beam with a special controlled power density profile (fusion drivers No. 1, No. 4) acting on the anode surface of the module (2.9), in the target explosion area (1.16) and in the body of the target (1.10.1) there are the initiation and evolution of a non-linear wave (see Fig. 11) which in the blow-up mode moves from the surface to the optical center of the target (1.10.1). In the central part of the target, the target's explosion occurs and the products of its explosion fly in all directions at high velocities of approximately 10^6 cm/s and more.

Fig. 11 shows the structure of a non-linear wave edge (shell) (11.2) with central symmetry (spherical, cylindrical, elliptical, and combinations thereof) in the target during coherent fusion initiation. On the left there is a cross section of the target through the center of symmetry and the non-linear wave edge (shell) moving in it. On the right there is an enlarged small fragment of the target and the non-linear wave edge (shell) to show its internal structure. The edge moves inside the target in the region (11.1) from its surface to its center of symmetry (11.8). The wave edge (11.2) propagates along the target in the active mode with a reactive force accelerating it due to the energy released by the evaporation of fusion products (11.6) from the trailing edge (11.5) of the nonlinear wave. During the fusion process, the non-linear wave edge (11.2) collides with the internal stationary central part (1.11) of the target, which is the fuel for this process. In this case, the non-linear wave edge (11.2) consists of a leading edge (11.3), a main

"body" (11.4) a trailing edge (11.5) and all boundaries of these regions.

11.2 – Non-linear wave edge with internal structure in a coherently correlated state (shell). The structure of the non-linear wave leading edge in the target through which the target substance enters the main body structures of the shell.

11.3 – Main "body" of the non-linear wave edge (shell) region with high density and nuclear fractal structures, in which fusion processes take place;

11.4 – Structure of the non-linear wave trailing edge;

11.5 – Region of fusion products evaporated from the non-linear wave trailing edge;

11.6 – Boundary of the target surface with the center of symmetry;

11.8 – Center of symmetry of the non-linear wave edge (shell) in the target.

A high voltage pulse is applied to the vacuum gap (2.14) between the cathode plasma flow (2.8) generated by the multicomponent cathode plasma module (2.7) and the anode plasma flow (2.10) generated by the anode plasma structures module (2.9). The distance between the cathode plasma module (2.7) and the anode plasma module (2.10) consists of the expanding area occupied by the cathode plasma (2.8), the anode plasma (2.10), and the gap (2.14). Whereas, plasma flows are controlled by fusion drivers No. 1, No. 2, and No. 4.

At the beginning of the process, the active resistance of the gap (2.14) is large (approximately thousands of Ohms) and, subsequently, it drops to zero when the gap disappears, while the resistance of the plasma conductor increases from zero to a value equal to the value of the resistance of a wire with a length equal to the initial gap between the cathode and the anode.

The current pulse is determined by the high voltage pulse applied to the diode and the diode impedance as a function of time. Obviously, the diode impedance is controlled by the temperature of the background discharge plasma and the time of plasma appearance in the gap between the cathode and the anode. The imaginary part of the impedance depends on the characteristic times of the process and is controlled by the shape of the voltage and current pulses (fusion driver No. 4). The current in the diode is determined by the modulus of its impedance. In typical cases, the diode resistance varies widely from thousands of Ohms at the beginning of the process to ones of Ohms and less during the course of the main processes in the target.

After the energy of the pulse impact is accumulated in the target body, a non-linear wave of density is initiated and develops, moving from the surface to the optical center of the target during the blow-up mode implosion.

There are fundamental qualitative differences between the non-linear wave in the self-organizing coherent inertial fusion method and the conventional inertial fusion method. In

contrast to conventional inertial fusion, in the coherent inertial fusion method, the wave edge is in a correlated coherent state and naturally separates the areas of "fuel" that enters the wave at its leading edge and the areas of combustion products that remain behind the wave's trailing edge.

At the same time, the non-linear wave edge forms a surface with central symmetry (spherical, cylindrical, ellipsoidal symmetries and/or their combinations). The following stages of inertial fusion take place: injection and ablation, compression, ignition of the fusion reaction, and explosion.

Under the influence of energy flows to the target surface during the energy absorption in the surface layer and at the moment of substance expansion from the surface (injection and ablation stage), a pressure pulse is created onto the target and a non-linear wave moving from the surface to the center is initiated. The wave edge is a shell, i.e. a "piston" that compresses the substance in front of it (compression stage). The energy of the external fusion driver is spent on this compression. After the fuel reaches the required density and temperature, the fusion reaction is initiated in the center (ignition stage). After the fusion reaction starts, the internal binding energy of the substance is rapidly released, an explosion occurs, and the substance begins to expand (explosion stage).

The shell plays a passive role here, i.e. it is a tool for compressing the central area of the target and transferring the substance in the center of the target to a state with a high probability of fusion reactions due to an increase in pressure and temperature. Due to the inertial properties of matter, this state is maintained for a certain time in a state with a fairly high probability of reaction even after the start of fusion reactions in the center, explosive energy release, and expansion of the substance.

The evolution of a non-linear wave in a target in coherent fusion under the action of a fusion driver is shown in Fig. 11. The difference from the processes in inertial fusion is that in coherent fusion the wave edge initiated near the target surface is transferred to a correlated coherent state by the pulsed external influence, providing that the wave edge is not a passive "piston" but an active object during its entire evolution.

Due to the movement of the wave edge which is in the correlated coherent state, the substance flow in the inner (central) part (11.1) of the target hits the area of the wave leading edge structure (11.3), and then it enters structures of the main body (11.4) of the shell, i.e. the area of fusion in states with suppressed Coulomb barriers. As a result of the "evaporation" of the synthesized nuclides, a stream of fusion products flows from the region of the trailing edge structure (11.5) to the region (11.6) behind the wave edge.

With a fairly rapid increase in the power of the fusion driver's influence on the target surface,

the dynamics of plasma field structures takes place in the explosive blow-up mode, during which and as a result of which the structure density increases in a self-consistent explosive manner under the conditions of electronic collapse and in a correlated coherent state.

The necessary conditions for achieving the stated technical result – obtaining energy in the process of thermonuclear fusion in the target due to the impact of the electron beam on the surface of its anode – are interdependent parameters of the main driver and the target. If these conditions are fulfilled this ensures the formation and initiation of a non-linear wave on the target surface. These conditions are quite feasible with modern equipment and are specified in the prior art sources **[21], [22], [23]**.

To improve the efficiency of the proposed technical solution and fulfill these basic conditions, plasma diodes and multi-component plasma cathodes described in **[15]** and **[25] are used.** These are metal electrodes made of heterogeneous elements with various coatings that facilitate the creation of plasma on their surfaces. When the drivers operate, all electrode surfaces are covered with plasma and a plasma anode system appears whereas the configuration of this plasma anode system changes with time as a result of plasma motion. The plasma moves both outside and inside the anode.

When the pulsed electron beam is focused on the surface of the target anode, the electrons of the beam penetrate the material to a certain depth $l_{\varepsilon}\left(U_{kV},\rho\right)\approx k_{coll}0.667\,U_{kV}^{5/3}\rho^{-1}$, which depends on the density ρ of the anode substance in grams per cubic centimeter, the electron energy corresponding to the potential difference U_{kV} in kilovolts and $0.3\le k_{coll}\le 1$ depending on the current density (with $k_{coll}\approx 1$ at low current density and $k_{coll}\approx 0.3$ at high current density). This dependence is one of the ratios that ensure the correct matching of the voltage pulse and the material of the anode and the target.

It can be assumed that a drift space between surfaces with zero potential is ensured near the surface. The electrons entering this layer form a certain distribution of potentials with a minimum in a certain area (the area of the virtual electrode) and the beam electrons reflected from this area appear.

The dynamics of the electron beam energy flow and the potential distribution in the anode under the action of a high voltage pulse are determined by the parameter $q_{VC}\left(U_{kV},j_{MA},\rho\right)\approx 6.2\,10^{-5}\,j_{MA}\left(t\right)U_{kV}^{11/6}\left(t\right)\rho^{-2}$.

If the current density $j_{MA}\left(t\right)$ in mega Amperes per square centimeter on the target and the energy of electrons at the moment of time t_1 satisfy the condition $q_{VC} > q_{cr1}\left(\rho_{\Omega}\right)$ then a system of virtual electrodes appears near the anode surface, in this system the fusion driver energy is

accumulated up to a certain moment of time t_2 in the voltage drop interval of the external pulse. This moment of time is determined by the condition $q_{VC} < q_{cr2}\left(\rho_{\Omega}\right)$. The expressions for the critical values include their dependence on the specific resistance ρ_{Ω} of the anode target material, which reflects a significant change in the threshold values with an increase in the specific electrical resistance ρ_{Ω}.

Thus, under optimal control of the fusion driver's influence on the target surface, the dynamics of plasma field structures takes place in the explosive blow-up mode, during which the structure density increases in a self-consistent explosive manner under the conditions of electronic collapse and evolution of a correlated coherent state (CCS). Such an electron collapse with positive feedback from the increase in density releases the binding energy of the substance's electrons in a process described in the collective monograph of Proton-21 LLC and other publications of its employees.

In the region of the wave edge, a quasi-potential plasma-field structure, which resembles a Bassard-Farnsworth inertial-electrostatic confinement fusion reactor in a highly non-stationary mode of this structure, moving with self-growing energy toward the center of the target is initiated.

The large accelerations at the wave edge in the blow-up mode implosion are the factors that transfer the interacting particles in the wave edge region into a correlated coherent state. In the CCS on the wave edge, on the way from the surface to the center of the target, conditions are created to suppress the Coulomb barrier and initiate fusion during the dynamic interaction of all particles with each other at extreme densities of electrons and accelerations in large volumes of the wave edge in the solid target, similar to fusion reactions in collapsing stars.

The complexity of nuclear fusion technology is related to the fact that, at relatively low energies of interacting particles, the probability of fusion processes and the transparency of Coulomb barriers $\sim exp\left(-2S_{eff}/\hbar\right)$ are extremely small due to the smallness of the Planck constant $\hbar$.

In non-inertial systems with an explosive change of accelerations, an explosive growth of the coherence coefficient and correlations κ_{ph} in the phase space of the system is initiated, and providing that the states become coherently correlated and the rapidly increasing accelerations are accompanied by the explosively growing effective Planck constant. For estimations, we can accept the fact that the properties of CCS can be understood by introducing the effective Planck constant $\hbar_{eff} = \hbar\frac{1}{\sqrt{1-\kappa_{ph}^2}}$ in accordance with the Schrödinger-Robertson relation.

Given that in the estimates of the probability of processes involving the Coulomb barrier, the effective Planck constant appears in the exponent, it becomes clear that the probability of fusion in the CCS may be increased by tens of orders of magnitude due to the control of the value κ_{ph} by controlling the change in the coherent acceleration in the system with the help of fusion drivers No. 1, No. 2, and No. 3 and the time characteristics of the voltage pulse.

The ability to control the probabilities of the fusion process not only by the temperature and pressure of the medium with interacting nuclei but also by the coherence of the process using additional fusion drivers and the non-stationarity of the medium makes it possible to significantly (by orders of magnitude) reduce the requirements for the parameters of "ignition" of fusion reactions and to realize these reactions not only in the center of the target but also on the path of a non-linear wave that self-compacts while moving to the center.

In each experiment carried out at the facilities of the latest generation, about 30÷35 kJ of energy was consumed from the network, about 10÷12 kJ of which was delivered to the target by means of an electron beam. As a result of the pulsed impact of an electron beam with such energy on the surface of a cylindrical target with a radius of about 4 mm, energy release processes were initiated in the blow-up mode and an explosion occurred in the central part of the target. The number of nucleons involved in the fusion process is determined by the target mass and fusion driver parameters, and their typical number in experiments at our facilities is in a wide range from ones 10^{19} to ones 10^{22}.

A distinctive feature of coherent fusion is that a macroscopic number of nuclei participates in the nuclear fusion processes; at the first stage, these nuclei actually form a single system – nuclear matter – due to the extremely high transparency of Coulomb barriers in CCS with high coherence, and then, when the stability threshold of this macroscopic nuclear system is reached, the system is split into the most stable droplets of nuclear matter. The mass numbers of stable droplets into which nuclear matter is split, in a wide range of matter densities from the density of a solid body to values of the order of 10^{37}, are in the range of 56÷61, i.e., within the "iron" peak.

To estimate the energy yield of such a reaction, let us consider the transformation of the initial macroscopic number of target nuclei from the most common stable isotope of lead, forming a set of clusters from a certain number of its nuclei. This number of nuclei is chosen so that the number of nucleons in the cluster coincides with the number of nucleons in the iron nuclei into which each cluster is split upon loss of stability. For the minimum cluster size, the reaction can be written as follows:

$$7\,(^{208}Pb) \rightarrow 26\,(^{56}Fe) + 102e$$

In this case, the initial nuclei and the nuclei of the reaction products contain 7*208 = 26*56 = 1456 nucleons. The binding energy of lead nuclei is 7.87 MeV per nucleon, while the binding energy of iron nuclei is 8.8 MeV per nucleon. Accordingly, for the above collective coherent nuclear reaction, the following change in the binding energy ΔB (and the respective mass defect $\Delta M = \Delta B / c^2$) is obtained:

$$\Delta B = 8.8\,1456 - 7.87\,1456 = (8.8 - 7.87)\,1456 = 0.93\,1456$$

Therefore, the energy of about one MeV per nucleon is released.

For typical targets made of boron, titanium, and lead, the energy yield of the reactions varies from tens of keV to MeV per nucleon (see Table 1).

Table 1. Target composition, collective reaction, and mass defect

	Hf	Pb	B	Ti	Cu	C	Si	Li^6D
Z and A nuclei	72, 178	82, 207	5, 11	22, 48	29, 63	6, 12	14, 28	(3+1), 8
Specific binding energy	8.0	7.87	6.927	8.72	8.76	7.68	8.447	4.275
Main collective reaction of iron synthesis	$56\,(^{178}Hf_{72}) \rightarrow \rightarrow 178\,(^{56}Fe_{26}) + 16e$	$7\,(^{208}Pb_{82}) \rightarrow \rightarrow 26\,(^{56}Fe_{26}) + 102e$	$56\,(^{11}B_5) \rightarrow \rightarrow 11\,(^{56}Fe_{26}) + 6e$	$56\,(^{48}Ti_{22}) \rightarrow \rightarrow 48\,(^{56}Fe_{26}) + 16e$	$56\,(^{63}Cu_{29}) \rightarrow \rightarrow 63\,(^{56}Fe_{26}) + 14e$	$56\,(^{12}C_6) \rightarrow \rightarrow 12\,(^{56}Fe_{26}) + 24e^+$	$56\,(^{12}C_6) \rightarrow \rightarrow 12\,(^{56}Fe_{26}) + 56e^+$	$56\,(Li^6D) \rightarrow \rightarrow 8\,(^{56}Fe_{26}) + 16e^+$
Mass defect, reactions MeV/ nucleon	0.8	0.93	1.873	0.08	0.04	1.12	0.353	4.52
Target density, g/cm^3	13.09	11.34	2.34	4.54	8.96	2.1	2.33	0.93

Typical targets are targets made of copper, titanium, lead, hafnium, polyethylene. The diameter of the target varies from 4 mm to 8 mm. The target parameters are consistent with the beam parameters, namely potential difference, current strength, duration of the beam power edge and the portion of the beam current hitting the target according to the above fusion conditions. The present application lists the main parameters of the target, namely its radius, density, and conductivity of the target material. The target parameters significantly affect the fusion process.

Taking into account the number of nucleons involved in the fusion process, the maximum total energy yield can be in the range of hundreds of kJ to hundreds of MJ in our experiments.

The explosion energy flows released in our experiments are represented by three main

components:

- energy flow of particles and plasma;
- energy flow of radiation and electromagnetic fields in a wide range of frequencies;
- energy flow of currents that have passed in the diode plasma spatial region of possible amplification in the time interval when the target explodes and expansion of products.

Experiments carried out at Proton-21 research facilities were always accompanied by measurements, both in online and offline modes. Voltage and current pulses in the diode, radiation in the optical range, and radiation in the X-ray and gamma ranges were measured in the online mode. Track measurements of fast particle and mass spectroscopic measurements were performed in the offline mode.

In the experiments at these Proton-21 facilities, the first results on self-organizing nuclear fusion in anode targets made of various materials were obtained and the fusion products of both light and heavy elements were experimentally studied.

High currents in the setup make it possible to obtain critical values of the current density on the target surface at target radii of several millimeters and, therefore, to capture a sufficiently large mass of matter in a non-linear wave moving toward the center. An explosion is initiated in the central area of the target, and the products of its explosion fly in all directions at velocities of about 10^7 cm/s.

In the case of implementation of the proposed method (coherent fusion), the control of the degree of correlation of matter in the CCS leads to the fact that fusion fuel elements do not have to be the lightest to produce sufficient power. Almost any material can be used as fuel, but the efficiency of energy yield will be somewhat different.

The target material can be almost any target material, provided that its size and beam parameters are properly matched. In the claimed invention, single component targets can be used, for example, as in the prototype [15], however, to increase efficiency, a combined target should be used. In such a target, in its central part, one of the thermonuclear fuels (preferably lithium deuteride) is placed. It is preferable to use polyethylene, lead, hafnium, titanium, aluminum as the outer part of the target, with outer target diameters from 4 mm to 8 mm.

The effectiveness of targets in our facilities is proven by optical and thermal measurements of energy flows after the target explosion. The amount of heat heating the body exceeds the energy delivered to the target.

Thus, to achieve the results described in this invention, the system has three additional fusion drivers (No. 1, No. 2, No. 3), which control the state of the electron beam and the target during the operation of main driver No. 4; the choice of the parameters of the drivers is aimed at achieving the condition of initiation of a non-linear implosion wave in the blow-up mode in

the general case of a multilayer target, where the upper layer of the target should be of a material with sufficiently low conductivity and have a fractal structure to increase the absorbed energy of the beam the driver parameters are optimized based on the condition that the acceleration of the beam power density absorbed in the surface layer ($a_P = \frac{(P_{dis}/V_{\text{int}})}{\tau_{eff}^2}$) exceeds the acceleration of the energy dissipation power density in the target ($a_T = \frac{n_0 T_{eff}}{\tau_{dis}^3}$); if this condition is met, a non-linear wave is formed in the blow-up mode and the target substance goes into an unstable state; i.e. a positive density feedback at the wave edge occurs and the internal energy of the electron shells of the substance is released, which together with the energy of the external driver moves to the central region of the target and an explosion of the central region of the target is formed: if there is thermonuclear fuel in the central region of the target, additional nuclear fusion reactions which also contribute to the release of internal energy of the substance and increase the efficiency of the explosion may be initiated.

The prevalence of elements in fusion products depends on the degree of disequilibrium and correlations in the fusion process. The results of studies of the shell structure of nuclei and the fractal structure of nuclear matter at a density lower than the density of nuclei under normal conditions can be used to explain the existence of superheavy stable elements in theory and experiments.

One of the accompanying phenomena of **coherent fusion** is a significant decrease in the radioactivity of reaction products compared to the initial radioactive targets and significant changes in the ratios between the accumulation rates of different nuclides in the initial mixtures of radioactive families. This can become a means of decontamination of radioactive waste and, in general, transformation of almost any toxic or unusable material into stable and safe elements, and, if necessary, accumulation of the necessary nuclides.

The anode explosion products – targets and expanding plasma flows – were observed by optical methods. At the same time, the estimated velocity of the explosion products was calculated using Doppler broadening of spectral lines, a time-of-flight (TOF) technique for recording the time of optical radiation reaching three points located at different distances from the center of the explosion, and high-speed photography of the explosion process and product expansion using high-speed CCD cameras. The obtained images allowed to estimate some characteristic times of the processes: the time for the plasma cloud which arose as a result of the target explosion to travel a 1 cm gap was about 50 ns, while the time for the copper cathode elements to bend was less than 500 ns.

During the processing of the measured optical spectra, first, the contribution from the

hardware functions of the device was excluded from the spectral line profiles, and then the measured spectrum was decomposed into separate spectral lines, and the width and shape of the lines were determined. In different experiments, the flow velocities vary but are mainly in the range from $2.0*10^6$ to $2.0*10^7$ cm/s. At the same time, all of the above methods for determining and calculating the velocity of flying particles gave close values. Fig. 12 shows our experimental data as evidence of the effectiveness of synthesis based on optical and thermal measurements – an example of determining the plasma expansion velocities from known distances between points and times of their passage.

Table 2 shows the composition and velocities of the flows of the lead target explosion products scattering from the center of the target, which were reconstructed with measurements of optical spectra (experiment number 41250).

Table 2. Element velocities in units of 10^7cm/s and percentage composition of flows from the explosion area, reconstructed with optical measurements

Element	**10^7cm/s**	**%**
H		2.15
C	0.263	1.48
B	0.742	0.72
Na	0.524	1.38
Al	0.222	2.03
Ca	0.540	1.84
Ti	0.442	1.56
Cr	0.251	0.56
Mn	0.321	2.26
Fe	0.501	5.74
Cu	1.040	10.39
Zn	0.525	8.67
Hf	0.402	0.89
Pb	0.914	60.34

Thus, the following values of the main components of the energy flows after the target explosion were obtained from the experiments:

- Taking into account that the mass loss during the explosion (obtained from the difference in the target mass before and after the explosion) ranges from 0.1 g to 0.9 g in various experiments, while the velocities of particles and plasma are on average in the range of (0.5-2)*10^7 cm/s, the energy of the target explosion products can be estimated as an average of 300 kJ to 1 MeV.
- Radiation energy flows and electromagnetic fields in a wide frequency range. The radiation energy flows from the explosion, hitting the elements of the blanket made of absorbing materials, heat it and the casing of the facility. In the most successful experiments, the heating

temperature of the blanket (2.13) measured at many points by temperature sensors shows that up to 25 kJ is converted into thermal energy, which results in an efficiency value of $Q_{Tag} \approx 2$, i.e., the output of thermal energy is up to 2 times higher than the energy delivered to the target (usually this energy is in the range from 10 kJ to 12 kJ).

- Energy flows of currents that have passed in the diode plasma spatial region of possible amplification in the time interval when the target explodes and there is an expansion of products. According to measurements in this part of the diode, in the best experiments, we obtain the value of the voltage pulse amplitude up to MV, the amplitude of the current pulse up to MA with a duration of about 50÷80 ns and the corresponding energy in the range of 60÷80 kJ. That is, the output of this type of energy is up to 2 times higher than the energy taken from the electric network (usually this energy is in the range from 30 kJ to 35 kJ).

Taking into account that the energy of the primary energy storage devices at the entrance to the plant was in the range of 30÷35 kJ, we conclude that the energy efficiency of the Proton-21 facility has reached an average value in the range of 10 to 30. Although the main efforts in the new facility were aimed at recording the energy of the explosion, the experiments also recorded fusion products in the form of rare elements, which also confirms the fusion processes in the target at the nuclear level.

The values of energy embedded in the target were calculated from measurements of voltage, current, and pulse duration. The voltage at the cathode was measured using a capacitive voltage divider. The current was measured using a Rogowski coil located in the cathode section of the facility. The voltage divider and a Rogowski coil were calibrated on the electrophysical bench in the Proton-21 laboratory. Signals were recorded using a Lecroy HDO 8108 oscilloscope.

The values of the released thermal energy were calculated by measuring the difference in temperature of the vacuum chamber before and after the discharge, taking into account its mass and heat capacity. Temperature measurements were carried out using thermocouples and a recording device (multifunctional thermometry bridge) TR-3200. The data of twenty experiments performed in the Proton-21 laboratory recently are presented in Table 3. Multicomponent targets were used during the study. In the column "target material" – the first symbol describes the material of the outer shell of the target (if there is only one symbol, the target is solid – a one-component target). The following symbols correspond to the material placed in the central part of the target.

The reproducibility of the results was confirmed by successful experiments of the Proton-21 research group in the mode of single explosions **[15]**. At the same time, the synthesis of new elements with energy yield **[24]** exceeding the energy delivered to the target was recorded (see Table 3). The fusion implemented and based on the technical solution of S. Adamenko **[15]** was

demonstrated to invited persons skilled in the art. The research results were published in international scientific journals **[17], [18]**.

Table 3. Results of measuring the beam energy and thermal energy released after the explosion

No. of experiment	Target material	Heat energy released, kJ	Beam energy, kJ	Q, from driver energy
SH42483	Ti+LiD+Li	17,6	8,1	2,2
SH42484	Cu+LiD+Li	15,1	8,0	1,9
SH42485	Cu+LiD+Li	12,3	7,6	1,6
SH42486	Cu+LiD+Li	14,9	10,8	1,4
SH42487	Ti	9,9	6,5	1,5
SH42488	Cu	10,5	8,2	1,3
SH42489	Cu+LiD+Li	11,5	6,2	1,9
SH42490	Cu	10,3	3,6	2,9
SH42491	Cu	9,7	6,3	1,5
SH42492	Ti	11,0	5,0	2,2
SH42493	Ti	17,3	4,9	3,5
SH42496	Ti+LiD+Li	16,0	3,6	4,4
SH42497	Cu+LiD+Li	14,0	2,8	5,0
SH42498	Cu+LiD+Li	7,4	5,1	1,5
SH42499	Ti+LiD+Li	11,3	3,8	3,0
SH42500	Ti	13,9	3,9	3,6
SH42506	Ti	11,4	2,4	4,8
SH42507	Ti	8,9	1,9	4,7
SH42508	Ti	7,8	3,5	2,2
SH42509	Cu+LiD+Li	4	2,4	3,9

The above description of the preferred embodiment of the claimed invention should be considered as an example that does not limit the scope of the claimed rights in any way. It is obvious that numerous possible modifications and variations of the claimed technical solutions may be well known to the persons skilled in the art. The described method and device are described to assist the persons skilled in the art in learning the principle of the invention operation and its practical application, with the possibility of using various modifications for a particular use or embodiment. The quantitative parameters of the invention, as well as its application, may differ depending on the tasks of a particular use or embodiment. The scope of invention is determined by claims enclosed hereto and their equivalents which contain terms used in their broadest sense, unless otherwise indicated. Also, it should be noted that embodiments (depending on the parameters of constituent units) described by persons skilled in the art may include variants that do not go beyond the scope of the claims.

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CLAIMS

1. A control system for nuclear processes and coherent nuclear fusion during the explosive blow-up mode of the self-harmonized electromagnetic confinement comprising the following components:

- an industrial electrical network module (1.0);
- a charging module (1.1) of the primary energy storage device;
- a primary energy storage device (1.2);
- main fusion driver No. 4 with a module (1.4) for delivering energy to the target, while the module (1.4) comprises a unit (1.4.1) for synchronizing the primary energy storage device (1.2) and generating energy flows of fusion driver No. 4;
- a reaction chamber (1.8);
- a grounded reverse current conductor (1.13);
- a target (1.10.1),

characterized in that the system further comprises:

- a module (1.10) for the sequential supply of targets (1.10.1) to the reaction chamber (1.8);
- a module (1.11) for the preparation of the reaction chamber (1.8);
- *additional fusion driver No. 1* with a module (1.7) for controlling plasma electrodes, while the module (1.7) comprises a unit (1.7.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 1 and a unit (1.7.2) for generating energy flows of fusion driver No. 1;
- *additional fusion driver No. 2* with a module (1.6) to control the initiation of the explosive blow-up mode, while the module (1.6) comprises: unit (1.6.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 2 and a unit (1.6.2) for generating energy flows of fusion driver No. 2;
- *additional fusion driver No. 3* with a module (1.5) to control the initiation of a non-linear wave in the target and modify properties of the target substance, while the module (1.5) comprises: unit (1.5.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 3 and a unit (1.5.2) for generating energy flows of fusion driver No. 3;
- while under the condition of optimal synchronization of units 1.4.1, 1.5.1, 1.6.1, and 1.7.1, additional fusion driver No. 3 also controls the process of initiating a non-linear wave with an edge (11. 2), which contains the leading edge structure (11.3) of the non-linear wave,

the main "body" (11.4) of the non-linear wave edge, and the trailing edge structure (11.5) of the non-linear wave and moves from the target surface (11.7) to its center of symmetry (11.8), whereas, the wave with the leading edge (11.3) moves in such a way that the target's inner central part (fusion fuel) (11.1) is in front of it, and the region (11.6) of fusion products evaporating from the trailing edge of the non-linear wave is behind it;

- while the module (1.4) for delivering energy to the target further comprises a unit (1.4.2) for coordinating the energy flows of fusion driver No. 4 and the target (1.10.1);
- output energy storage device No. 1 (1.17);
- output energy storage device No. 2 (1.18);
- a module (1.3) for controlling a primary energy storage device (1.2), a unit (1.4.1) for synchronizing the primary energy storage device (1.2) and generating energy flows of fusion driver No. 4; a unit (1.4.2) for coordinating energy flows of fusion driver No. 4 and the target (1.10.1); a unit (1.5.1) for coordinating and synchronizing energy of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 3; a unit (1.5.2) for generating energy flows of fusion driver No. 3; a unit (1.6.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 2; a unit (1.6.2) for generating energy flows of the fusion driver No. 2; a unit (1. 7.1) for coordinating and synchronizing energy flows of the primary energy storage device (1.2) and energy flows of additional fusion driver No. 1; a unit (1.7.2) for generating energy flows of fusion driver No. 1; a module (1.11) for the preparation of the reaction chamber (1.8) and a module (1.10) for the sequential supply of targets (1.10.1);
- while the module (1.14) for converting the kinetic energy flow of fusion products from the target explosion area (2.16) comprises a unit (1.14.1) for taking kinetic energy of fusion products and a unit (1.14.2) for coordinating converted energy with the unit of output energy storage devices No. 1 (1.17);
- the module (1.15) for converting the electromagnetic radiation energy flow from the target explosion area (2.16) comprises a unit (1.15.1) for taking electromagnetic radiation energy from the target explosion area and a unit (1.15.2) for coordinating the converted energy with the output energy storage unit No. 1 (1.17);
- the module (1.16) for converting the energy flow in the return current conductor with grounding (1.13) comprises a unit (1.16.1) for taking the energy of currents of the grounded return current line (1.13) and a unit (1.16.2) for coordinating the converted energy with output energy storage unit No. 2 (1.18);
- a module (1.19) for coordinating the unit of output energy storage devices No. 2 (1.18) with the primary energy storage device (1.2);

wherein the system contains the above-mentioned three additional fusion drivers (*No. 1, No. 2, No. 3*) controlling the state of the electron beam and the target during the operation of main driver No. 4;

the choice of parameters of the above drivers is aimed at achieving the condition of initiation of a non-linear implosion wave in the blow-up mode in the general case in a multilayer target, where the upper layer of the target should be made of a material with sufficiently low conductivity and have a fractal structure to increase the values of the absorbed energy of the beam;

wherein the driver parameters are subjected to optimization based on the condition of exceeding the acceleration of the absorbed power density in the surface layer of the beam calculated by formula $a_P = \frac{(P_{dis}/V_{\text{int}})}{\tau_{eff}^2}$ over the acceleration of the power density of energy dissipation in the target calculated by formula $a_T = \frac{n_0 T_{eff}}{\tau_{dis}^3}$, where a_p – evolution impact, P_{dis} – power density of the driver energy, *Vint* – absorbed in the near-surface volume, τ_{eff} – target during the characteristic time, a_T – acceleration of the power density of dissipative losses, n_0 – is the density of the medium, T_{eff} is the temperature of the medium, and τ_{dis} is the characteristic time of dissipation, when this condition is met, a non-linear wave in the blow-up mode is formed and the substance of the target goes into an unstable state, i.e. a positive density feedback at the wave edge occurs and the internal energy of the electron shells of the substance is released, which together with the energy of the external driver moves to the central region of the target and an explosion of the central region of the target is formed,

wherein if there is thermonuclear fuel in the central region of the target, additional nuclear fusion reactions which also contribute to the release of internal energy of the substance and increase the efficiency of the explosion may be initiated.

2. The system according to claim 1, **characterized in that** the reaction chamber (1.8) comprises the following components:

- the plasma guns (2.1) of fusion driver No. 1, preferably arranged with central symmetry around the axis of the reaction chamber and designed to generate plasma (2.6) of the reaction chamber;
- the electromagnetic field generators (2.2) of fusion driver No. 1, preferably arranged with central symmetry around the axis of the reaction chamber;
- the plasma guns (2. 3) of fusion driver No. 2, preferably arranged with central symmetry around the axis of the reaction chamber;

- the electromagnetic field generators (2.4) of fusion driver No. 2, preferably arranged with central symmetry around the axis of the reaction chamber;
- the radial current field generators (2.5) of fusion driver No. 3, preferably arranged with central symmetry around the axis of the reaction chamber;
- a multicomponent cathode plasma module (2.7) designed to generate a cathode plasma flow (2.8);
- anode plasma structures module (2.9) designed to generate anode plasma flow (2.10);
- a unit (2.11) of coils of a special structure of the module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16) to excite voltage and current pulses in their elements initiated by the kinetic energy flow of explosion products of the target (1.10.1);
- a housing (2.12) of the reaction chamber (1.8);
- a target explosion area (2.16);
- a module (2.13) for taking the flow of high-level radiation energy from the target explosion area (2.16) with a blanket for absorbing high-level radiation and taking thermal energy;
- a gap (2. 14) between the cathode and anode plasma flows;
- a module (2.15) for taking the current energy flow that passed the target explosion area (2.16) and the anode plasma structures module (2.9).

3. The system according to claims 1 to 2, **characterized in that** fusion driver No. 1 comprises the following components:

- a module for synchronizing the pulse equipment with the signal from the module (1.3);
- a source (4.2) of pulsed current and voltage;
- a module (4.3) for setting the signal offset;
- the plasma guns (4. 4) for focusing the electron beam;
- a module (4.5) for generating pulsed electromagnetic radiation and/or laser radiation to control the initiation of emission processes by the cathode unit of fusion driver's No. 1.

4. The system according to claims 1 to 3, **characterized in that** fusion driver No. 2 comprises the following components:

- a module (5.1) for synchronizing the pulse equipment with the signal from the module (1.3);
- a source (5.2) of pulsed current and voltage;
- a module (5.3) for setting the signal offset;
- a plasma gun (5.4) for focusing the electron beam of fusion driver No. 2;

- a module (5.5) for generating pulsed electromagnetic radiation and/or laser radiation to control the shape of the beam current and the processes for generating the blow-up mode in the target (1.10.1).

5. The system according to claims 1 to 4, **characterized in that** fusion driver No. 3 comprises the following components:

- a module (6.1) for synchronizing the pulse equipment with the signal from the module (1.3);
- a source (6.2) of pulsed current and voltage;
- a module (6.3) for setting the signal offset;
- a module (6.4) for generating radial currents to focus and/or self-focus the electron beam on the target surface (1.10.1); and/or
- a module (6.5) for generating pulsed electromagnetic radiation with longitudinal polarization to control the blow-up mode in the target (1.10.1).

6. The system according to claims 1 to 5, **characterized in that** the module (1.14) for converting the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16) further comprises the following components:

- a module's condensed working medium (7.1) made of the ferroelectric and/or ferromagnetic material and/or a finely dispersed mixture of dielectric and conductive components;
- a unit (7.2) for taking the energy flow of voltage and current pulses initiated in the condensed working medium (7.1) by the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16);
- a module (7.3) for coordinating the output energy flow of the unit (7.2) with the unit of output energy storage devices No. 1 (1.17);
- the unit of output energy storage devices No. 1 (1.17).

7. The system according to claims 1 to 6, **characterized in that** the module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area **(2.16)** further comprises the following components:

- a unit (8.1) for taking the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16);
- a transmission line (8.2) for transmitting the target explosion energy taken in the unit (8.1) to the module (8.3) for transforming and coordinating the flows of the taken energy with the unit of output energy storage devices No. 1 (1.17);
- a module (8.3) for transforming and coordinating the flows of the taken energy with the

unit of output energy storage devices No. 1 (1.17);

8. The system according to claims 1 to 7, **characterized in that** the module (1.9) for taking the kinetic energy flow (1.12) of fusion products and high-level radiation energy from the target explosion area (2.16) further comprises the following components:

- a unit (9.1) for converting the energy released in the module blanket (2.13) into electrical and/or thermal energy;
- an electrical energy storage unit (9.2);
- a thermal energy storage unit (9.3).

9. The system according to claims 1 to 8, **characterized in that** the reaction chamber (1.8) further comprises a multicomponent cathode plasma module (2.7) and an anode plasma structures module (2.9).

10. The system according to claims 1 to 9, **characterized in that** unsteady plasma electrical and electromagnetic structures are placed additionally in the focusing zone of the electron beam, providing an impact sufficient to change the energy direction of the processes, while electromagnetic sources and high-voltage discharge plasma generated by plasma guns and/or laser sources are used to control their implementation.

11. The system according to claims 1 to 10, **characterized in that** in the reaction chamber (1.8), the system further comprises toroidal electromagnetic field generators (2.4) of fusion driver No. 2 and the radial current field generators (2.5) of fusion driver No. 3 to control the value of the Coulomb barrier and the internal structure of the fuel nuclei of reactor target (1.10.1).

12. The system according to claims 1 to 11, **characterized in that** the reaction chamber (1.8) further comprises a module (1.14) for converting the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16); a module (1.15) for converting the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16); a module (1.16) for converting the energy flow (1.20) in the reverse current area in the grounded reverse current conductor (1.13).

13. The system according to claims 1 to 12, **characterized in that** the system comprises more than one additional fusion driver No. 1 and/or additional fusion driver No. 2 and/or additional fusion driver No. 3.

14. A method for controlling nuclear processes and coherent nuclear fusion during the explosive blow-up mode of the self-harmonized electromagnetic confinement according to the system described in claims 1 to 13, **characterized in that** it includes the following steps:

- with the charging module (1.1) of the primary storage unit, the energy supplied from the industrial electrical network module (1.0) is accumulated in the primary energy storage unit

(1.2);

- with the module (1.3), the primary energy storage device (1.2), units (1.4.1, 1.4.2, 1.5.1, 1.5.2, 1.6.1, 1.6.2, 1.7.1, 1.7.2) of fusion drivers, the module (1.11) for the preparation of the reaction chamber (1.8), and the module (1.10) for the supply of targets (1.10.1) are controlled;
- with the module (1.10), a sequential supply of targets (1.10.1) into the reaction chamber (1.8) with a specified repetition rate is implemented;
- with the module (1.11), the reaction chamber (1.8) is prepared;
- with the unit (1.7.1), the energy flows of the primary energy storage device (1.2) and the energy flows of additional fusion driver No. 1 are coordinated and synchronized;
- with additional fusion driver No. 1, the medium around the target (1.10.1) is prepared in the reaction chamber (1.8) to ensure primary ionization of the target surface layer;
- with the unit (1.4.1), the energy flows of the primary energy storage device (1.2) and the energy flows of main fusion driver No. 4 are generated and synchronized;
- with the unit (1.6.1), the energy flows of the primary energy storage device (1.2) and the energy flows of additional fusion driver No. 1 are coordinated and synchronized;
- with additional fusion driver No. 2 and the unit (1.4.2) of fusion driver No. 4, the power profile of the energy flow from main fusion driver No. 4 is formed depending on the time;
- with additional fusion driver No. 2 and the unit (1.3), the moment of initiation of the blow-up mode is controlled and energy is accumulated in the surface layer of the target to initiate a non-linear wave;
- with additional fusion driver No. 2, the blow-up mode is initiated in the reaction chamber's (1.8) medium around the target (1.10.1) and in the target itself to ensure the primary ionization of the surface layers of the condensed matter;
- with the unit (1.5.1), the energy flows of the primary energy storage device (1.2) and the energy flows of additional fusion driver No. 3 are coordinated and synchronized;
- with additional fusion driver No. 3, the properties of target materials and fusion processes are controlled at the initial stage of the blow-up mode;
- with additional fusion driver No. 3 and additional fusion driver No. 2, the following processes are controlled:
  - initiation of the beginning of the edge (11.2) movement of the non-linear wave in the correlated coherent state with the center of symmetry (11.8) and the internal structure of the leading edge structure (11.3) moving from the surface (11.7) to the center of symmetry (11.8) of the target;
  - the state of the main "body" (11.4) of the non-linear wave edge, the structure of the

trailing edge structure (11.5) of the non-linear wave,

while the target's inner central part (fusion fuel) (11.1) is located in front of the non-linear wave, while the region (11.6) of fusion products evaporating from the trailing edge of the non-linear wave is located behind it;

- with the module (1.14), the kinetic energy of fusion products is converted into electrical energy;
- with the module (1.14.2), the converted energy is coordinated with the unit of output energy storage devices No. 1 (1.17).
- with the module (1.15), the flow of kinetic energy of the fusion products from the target explosion area is converted into electrical energy;
- with the unit (1.15.2), the flow of converted energy is coordinated with the unit of output energy storage devices No. 1 (1.17) and the received energy is accumulated in output energy storage device No. 1 (1.17).
- with the module (1.9), the flow of kinetic energy of the fusion products from the target explosion area (2.16) is converted into electrical energy and/or thermal energy;
- with the unit (1.16.1), the energy flow (1.20) of currents of the grounded reverse current conductor (1.13) is taken;
- with the unit (1.16.2), the taken energy is coordinated with output energy storage device No. 2 (1.18);
- with the module (1.19), the unit of output energy storage devices No. 2 (1.18) is coordinated with the primary energy storage device (1.2), and the kinetic energy of the fusion products and the energy of electromagnetic radiation are taken.

15. The method according to claim 14, **characterized in that** it further includes the following steps:

- With the module (4.1), the signals of the pulse equipment of fusion driver No. 1 are synchronized with the module (1.3);
- With the source (4.2), a pulse current and voltage are generated;
- With the module (4.3), the offset of the signals of fusion driver No. 1 is initiated;
- With the plasma gun (4.4), the electron beam of fusion driver No. 4 is focused;
- with the module (4.5), pulsed electromagnetic radiation and/or laser radiation are generated to control the initiation of emission processes by the cathode unit of fusion driver No. 4.

16. The method according to claims 14 to 15, **characterized in that** it further includes the

following steps:

- with the module (5.1), the signals of the pulse equipment of fusion driver No. 2 are synchronized;
- with the source (5.2), the pulse current and voltage of fusion driver No. 2 are generated;
- With the module (5.3), the offset of signals of fusion driver No. 2 is initiated;
- with the plasma gun (5.4), the electron beam of fusion driver No. 4 is focused;
- with the module (5.5), pulsed electromagnetic radiation and/or laser radiation of fusion driver no.2 are generated to control the shape of the beam current and the processes for generating the blow-up mode in the target (1.10.1).

17. The method according to claims 14 to 16, **characterized in that** it further includes the following steps:

- with the module (6.1), the signals of the pulse equipment of fusion driver No. 3 are synchronized with the signal of the module (1.3);
- with the source (6.2), the pulse current and voltage of fusion driver No. 3 are generated;
- with the module (6.3), the offset of the signals of fusion driver No. 3 is initiated;
- with module (6.4), radial currents of the electron beam that self-focuses on the target surface (1.14) are generated, and/or
- with the module (6.5), pulsed electromagnetic radiation with longitudinal polarisation is generated to control the blow-up mode in the target (1.10.1) and the properties of the target materials in the target explosion area.

18. The method according to claims 14 to 17, **characterized in that** the kinetic energy of the target explosion is converted into electrical energy accumulated in the system of output energy storage devices No.1 **(1.17)**, while:

- with the impact of explosion products flow (1.22) of the target (1.10.1) in the condensed working medium (7.1) made of the ferroelectric and/or ferromagnetic material and/or a finely dispersed mixture of dielectric and conductive components, a polarization wave propagating through the medium is initiated;
- with the unit (7.2) for taking the energy flow of voltage and current pulses initiated in the condensed working medium (7.1) by the kinetic energy flow (1.22) of fusion products from the target explosion area (2.16), voltage and current pulses initiated by a polarization wave in the working medium (7.1) are excited;
- with the module (7.3), the output energy flow of the unit (7.2) is coordinated with the unit of output energy storage devices No. 1 (1.17);
- with the unit of output energy storage devices No. 1 (1.17), the received electrical

energy is accumulated.

19. The method according to claims 14 to 18, **characterized in that** the energy of the current and electromagnetic fields that have passed through the explosion area is converted into electrical energy accumulated in the system of energy storage devices No.1 **(1.17)**, while:

- with the unit (8.1) for taking the current and electromagnetic fields energy flow (1.23) from the target explosion area (2.16), the energy flow that has passed the target explosion area (2.16) and the transmission lines is coordinated;
- with the transmission line (8.2), the flow of the taken target explosion energy is transmitted to the module (8.3) for coordinating and transforming the pulse power;
- in the module (8.3), the pulse power is coordinated and transformed from relatively high values after the explosion of the target (1.10.1) to the power values necessary for efficient energy storage in the unit of output energy storage devices No. 1 (1.17).

20. The method according to claims 14 to 19, **characterized in that** the energy of the radiation and explosion plasma is converted into electrical and thermal energy, while:

- with the module (2.13) and the unit (9.1), the energy flows (1.12) of high-level radiation and fusion products resulting from the fusion processes in the target explosion area (2.16) are converted into thermal and/or electrical energy;
- electrical energy is accumulated in the unit (9.2);
- thermal energy is accumulated in the unit (9.3).

21. The method according to claims 14 to 20, **characterized in that** the energy of the current and electromagnetic fields that have passed through the explosion area and the reverse current conductor is converted into electrical energy accumulated in the system of output energy storage devices No. 2 **(1.18)**, while:

- with the unit (10.1) the energy flow (1.20) of the currents of the grounded reverse current conductor (1.13) is taken;
- the flow of the taken target explosion energy is transmitted via the line (10.2) to the module (10.3) for transforming and coordinating the pulse power;
- in the module (10.3), the pulse power is coordinated and transformed from relatively high values after the explosion of the target (1.10.1) to the power values necessary for efficient energy storage in the unit of output energy storage devices No. 2 (1.18).

22. The method according to claims 14 to 21, **characterized in that** the process is implemented using heterogeneous and non-stationary high-voltage discharge plasma structures (2.6, 2.8, 2.10) generated in the focusing zone of the electron beam using plasma guns and/or laser sources, which provides an impact sufficient to change the energy direction of the processes.

23. The method according to claims 14 to 22, **characterized in that**, to implement the process, the value of the Coulomb barrier and the internal structure of the fuel nuclei of the reactor target (1.10.1) are controlled by toroidal electromagnetic field generators (2.4) and radial current field generators (2.5).

24. The method according to claims 14 to 23, **characterized in that** more than one additional fusion driver No. 1 and/or additional fusion driver No. 2 and/or additional fusion driver No. 3 are used to implement the process.

25. The method according to claims 14 to 24, **characterized in that**, to implement the process, the kinetic energy of the fusion products and the electromagnetic radiation due to the fusion processes in a wide range of energies is converted into electrical energy which can be used for other purposes or accumulated in energy storage devices.

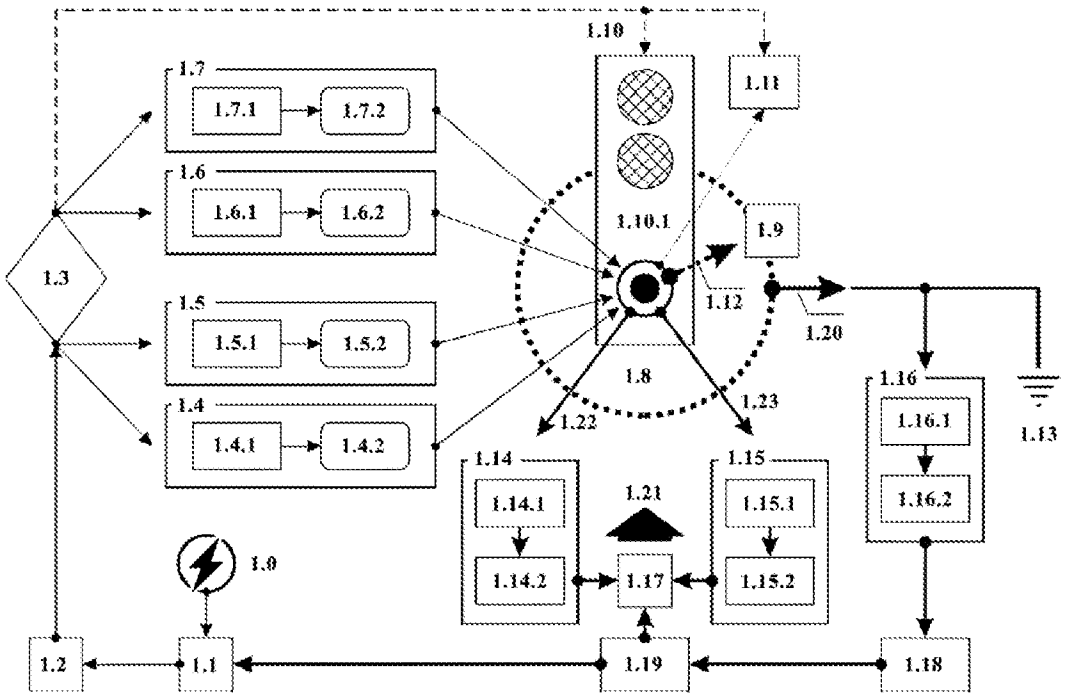

1.10
1.11
1.7
1.7.1
1.7.2
1.6
1.6.1
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1.10.1
1.9
1.3
1.5
1.5.1
1.5.2
1.12
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1.8
1.16
1.16.1
1.16.2
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1.4.1
1.4.2
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1.21
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1.2
1.1
1.19
1.18

Fig. 1

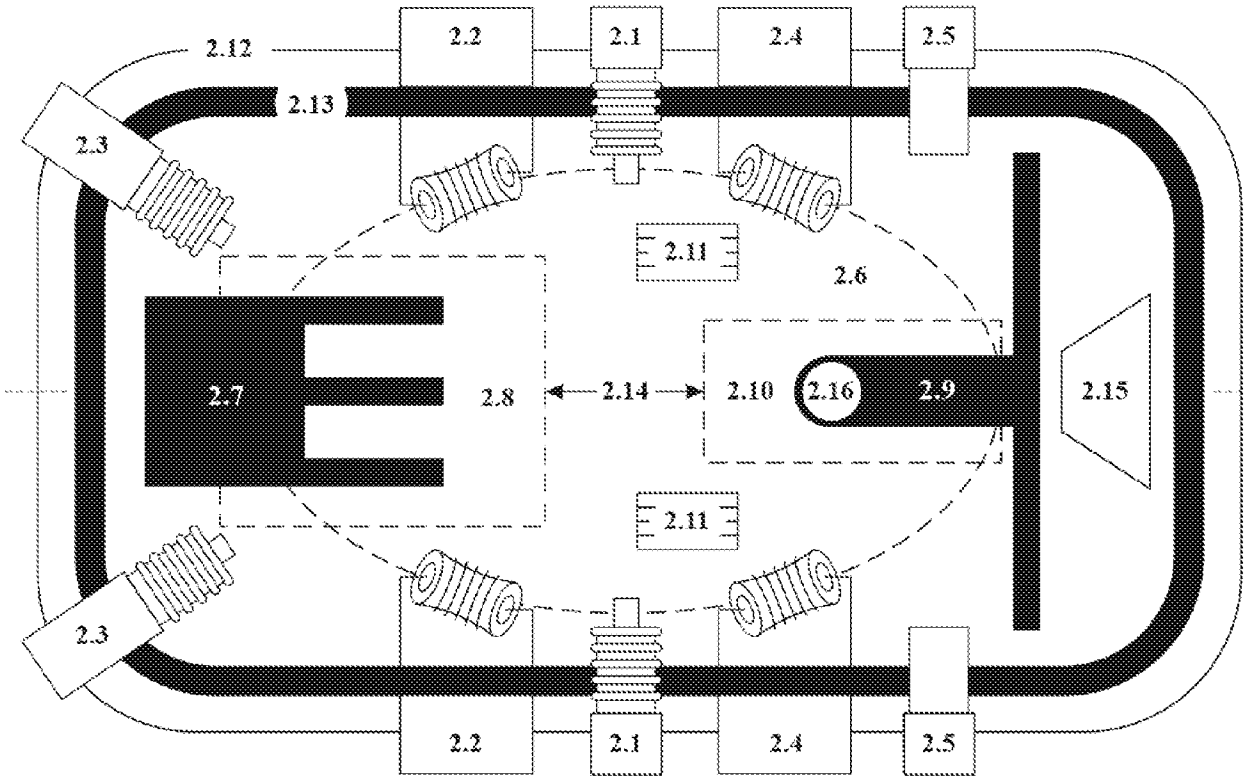

2.12
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2.4
2.5

Fig. 2

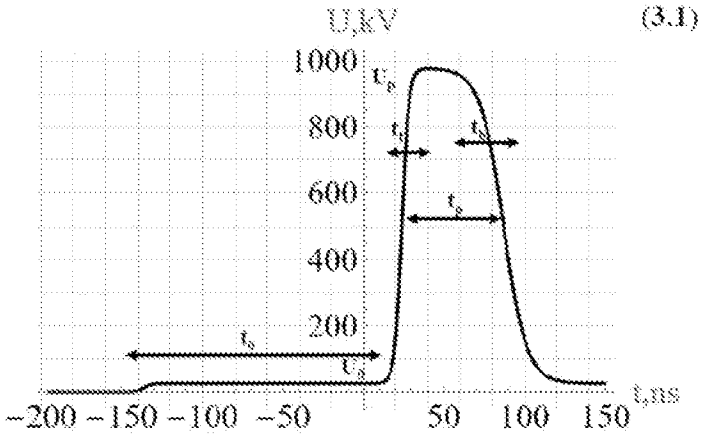


Fig. 3.1

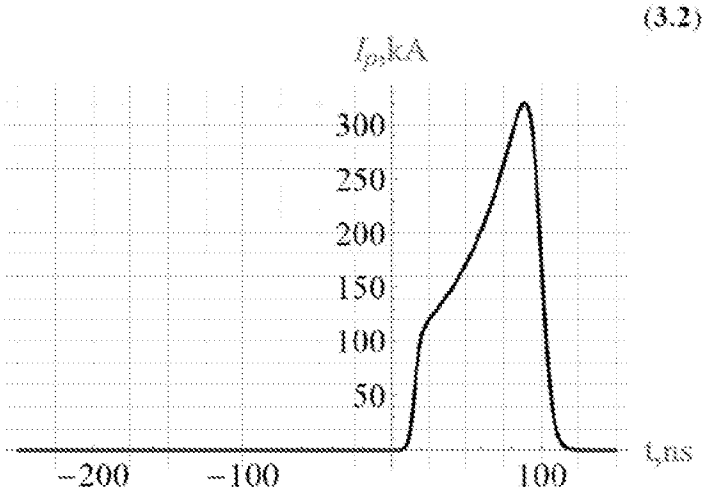


Fig. 3.2

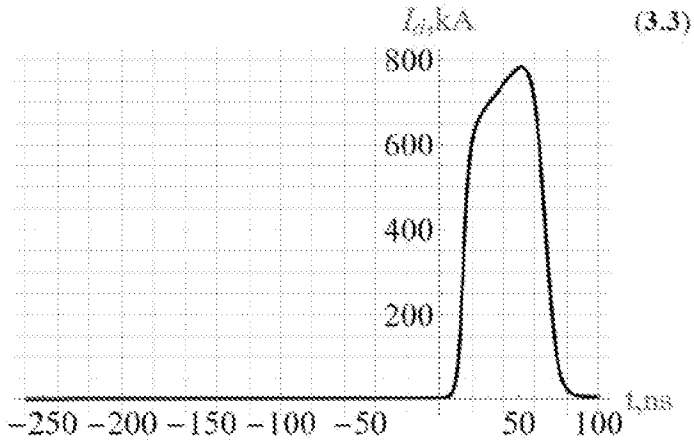


Fig. 3.3

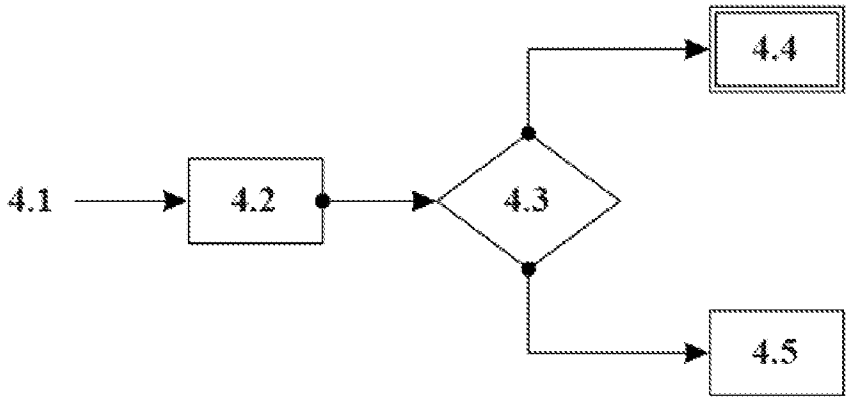


Fig. 4

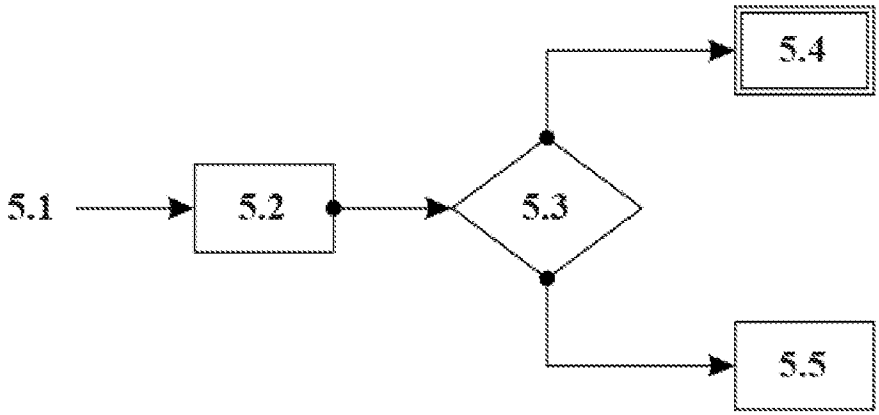


Fig. 5

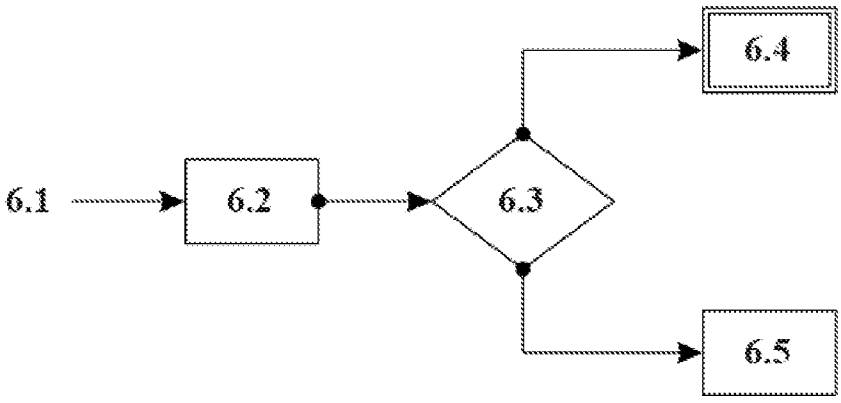


Fig. 6

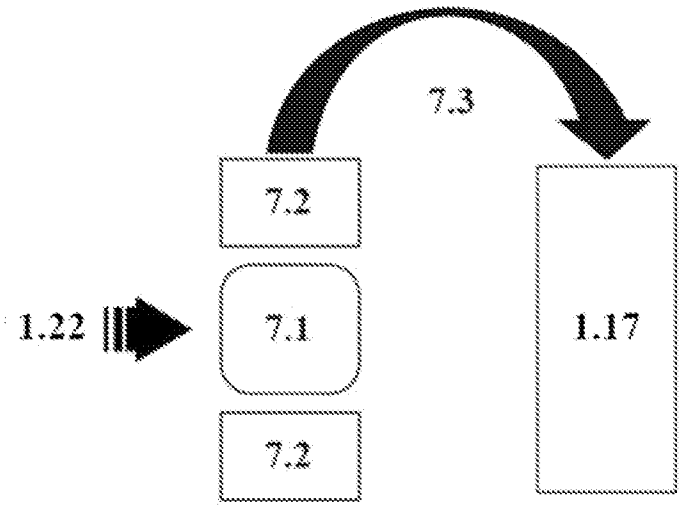


Fig. 7

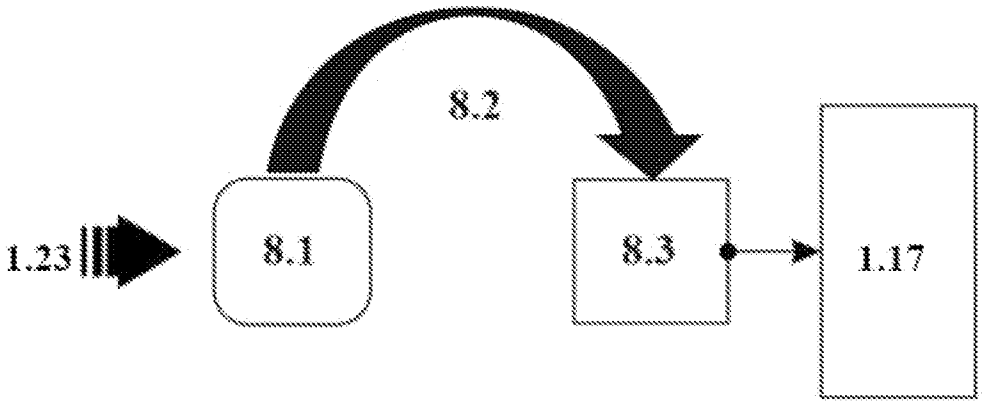


Fig. 8

5

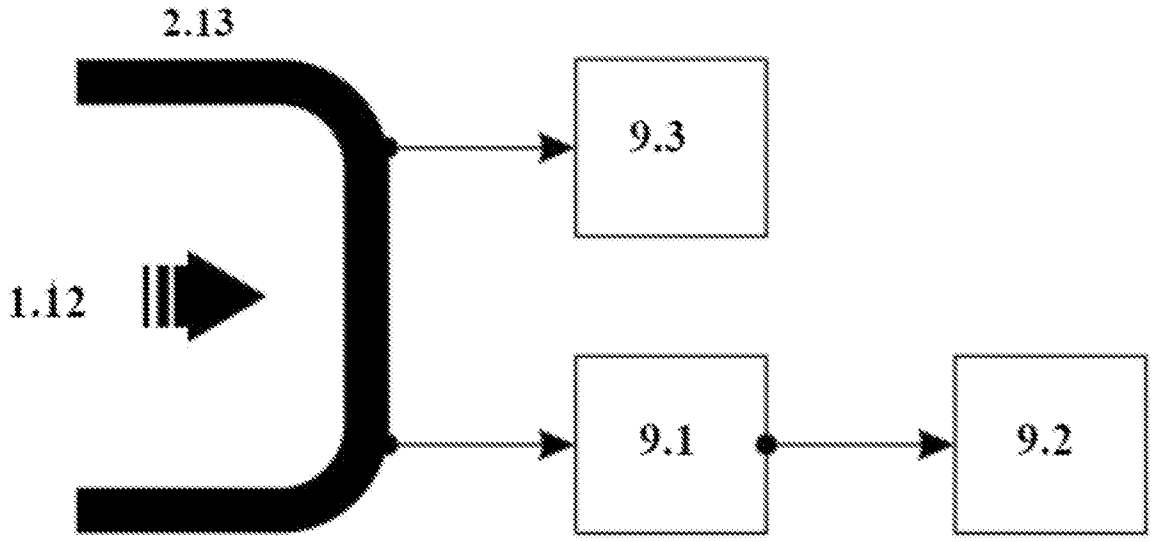


Fig. 9

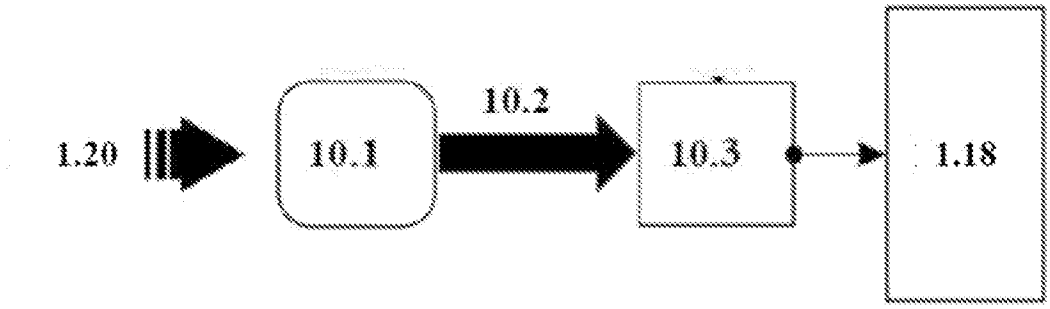


Fig. 10

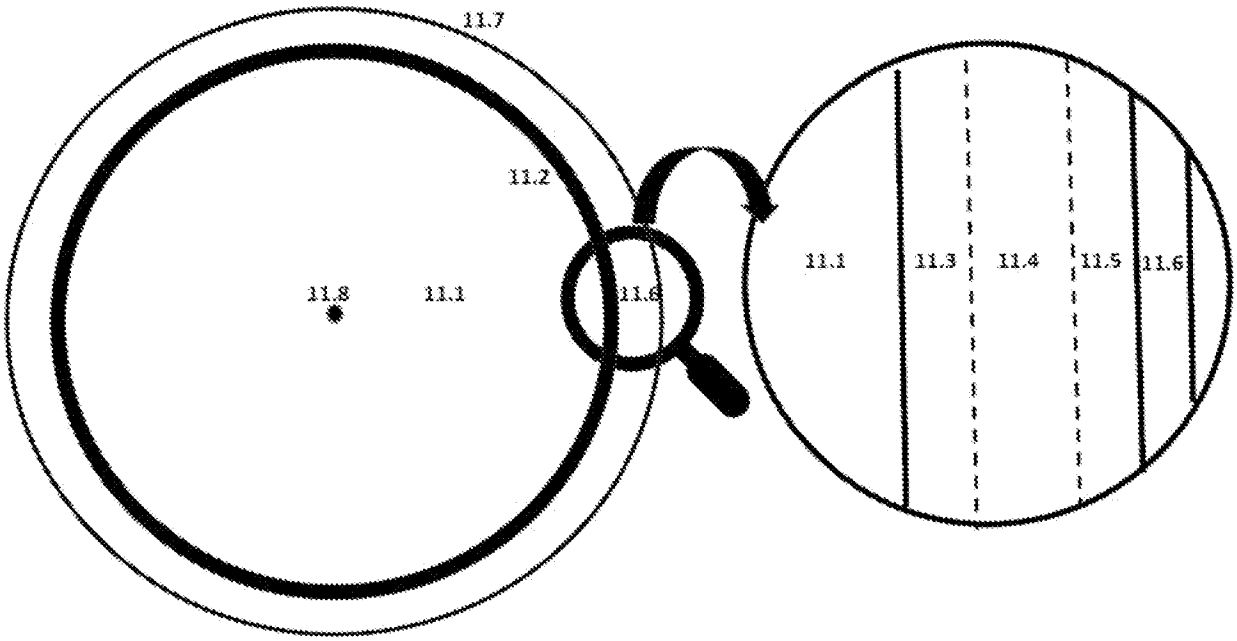

11.7
11.2
11.8
11.1
11.6
11.1
11.3
11.4
11.5
11.6

Fig. 11

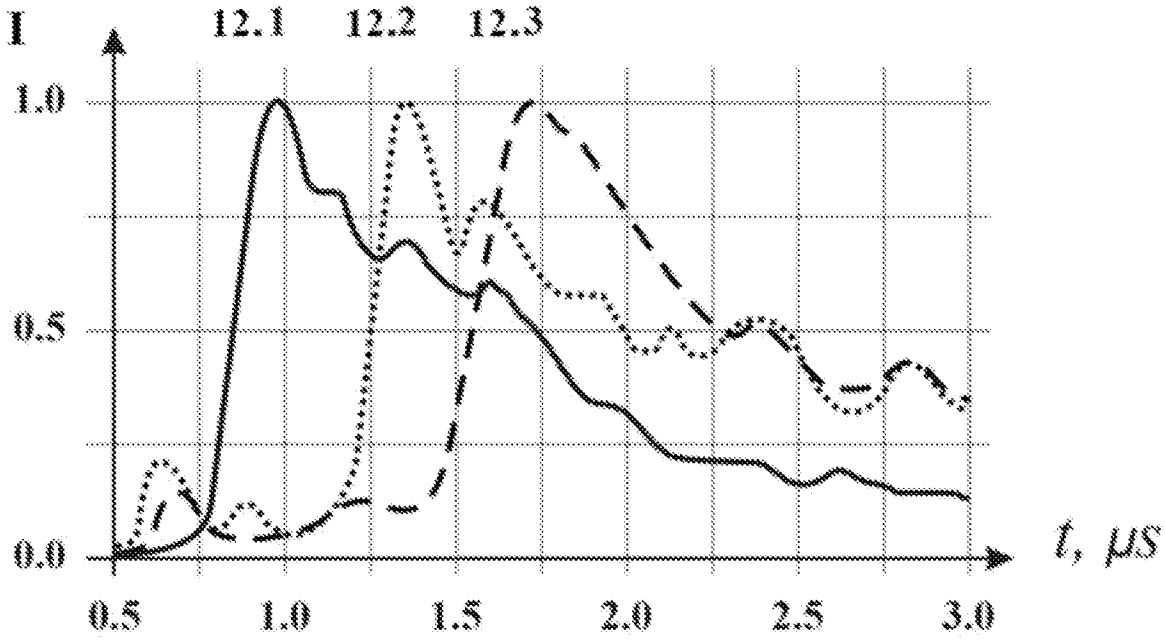
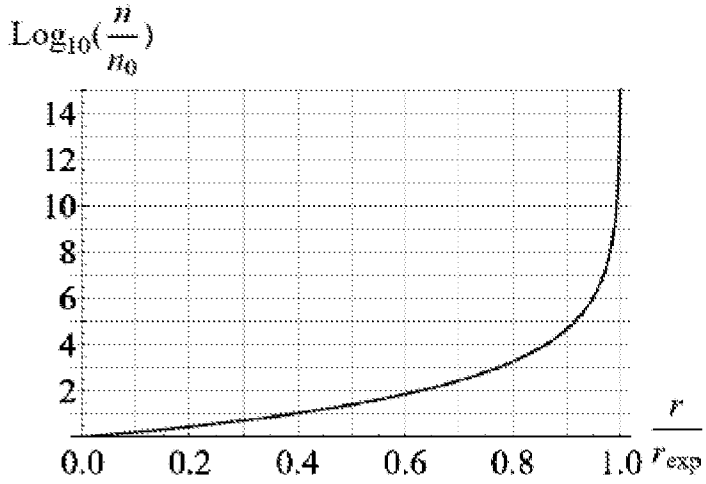

I
12.1
12.2
12.3
1.0
0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
t, μS

Fig. 12

(13.1)



(13.2)

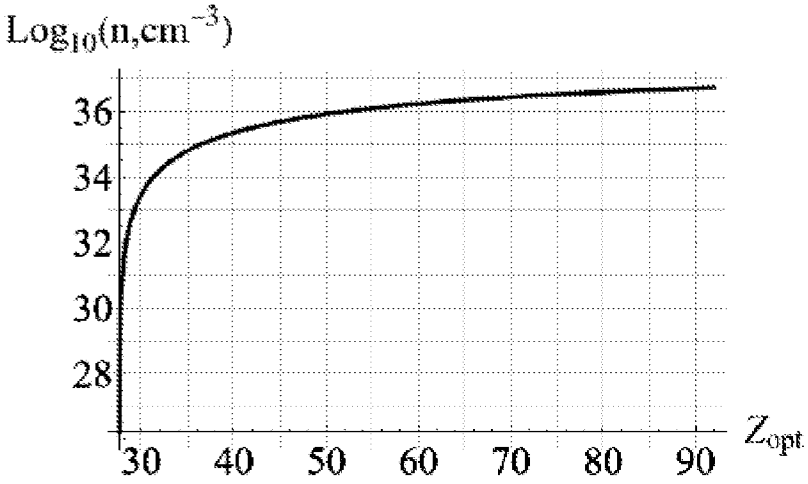


Fig. 13

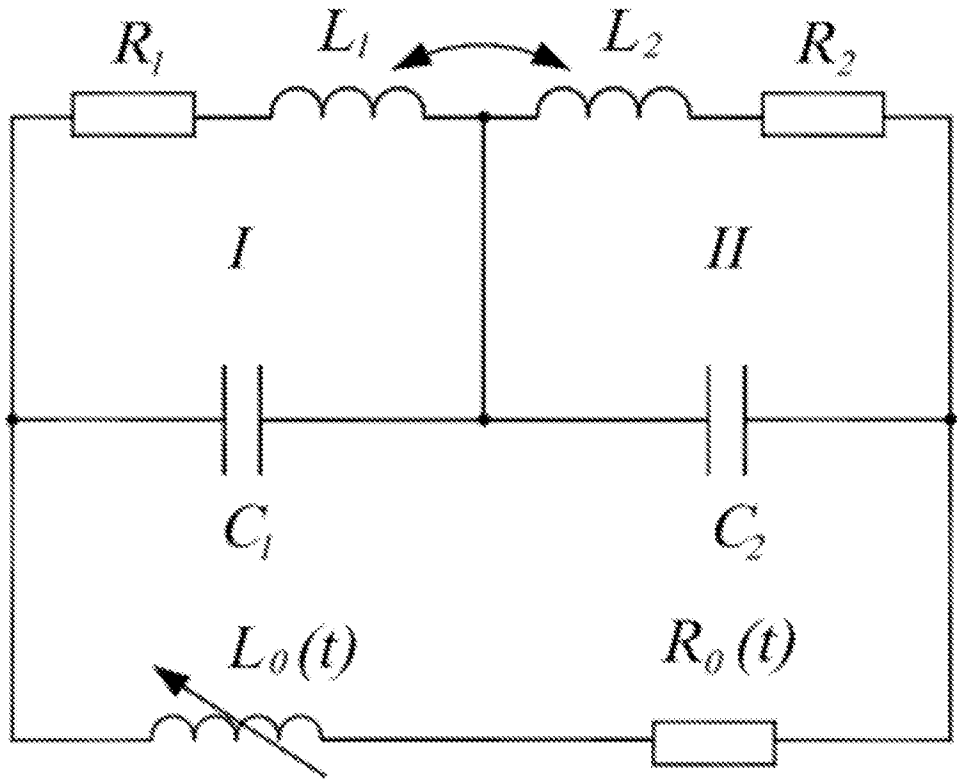


Fig. 14

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13*ter*.1(c) and Rule 39)

Applicant's or agent's file reference	IMPORTANT DECLARATION	Date of mailing(day/month/year)
Proton-24		15 November 2024 (15-11-2024)
International application No.	International filing date(day/month/year)	(Earliest) Priority date(day/month/year)
PCT/IB2024/057678	8 August 2024 (08-08-2024)	9 August 2023 (09-08-2023)
International Patent Classification (IPC) or both national classification and IPC		
G21B1/03, G21B1/11		
Applicant		
TOVARYSTVO Z OBMEZHENOU VIDPOVIDALNISTIU		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below

1. ☐ The subject matter of the international application relates to:
   - a. ☐ scientific theories
   - b. ☐ mathematical theories
   - c. ☐ plant varieties
   - d. ☐ animal varieties
   - e. ☐ essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes
   - f. ☐ schemes, rules or methods of doing business
   - g. ☐ schemes, rules or methods of performing purely mental acts
   - h. ☐ schemes, rules or methods of playing games
   - i. ☐ methods for treatment of the human body by surgery or therapy
   - j. ☐ methods for treatment of the animal body by surgery or therapy
   - k. ☐ diagnostic methods practised on the human or animal body
   - l. ☐ mere presentations of information
   - m. ☐ computer programs for which this International Searching Authority is not equipped to search prior art
2. ☒ The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:
   ☒ the description ☐ the claims ☐ the drawings
3. ☐ A meaningful search could not be carried out without the sequence listing; the applicant did not, within the prescribed time limit:
   - ☐ furnish a sequence listing complying with WIPO Standard ST.26, and such listing was not available to the International Searching Authority in a form, language and manner acceptable to it.
   - ☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13*ter*.1(a).

4. Further comments:

Name and mailing address of the International Searching Authority

European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040

Authorized officer

REGINELLI, Francesca
Tel:+49 (0)89 2399-2814

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 203

Consistently with the wording of independent claims 1 and 14, the gist of the present invention consists in a control system and a corresponding method for controlling nuclear processes and coherent nuclear fusion during the explosive blow-up mode of the self-harmonized electromagnetic confinement. More precisely, consistently with the description, the invention relates to nuclear fusion in condensed matter, in which controlled self-consistent pycnonuclear processes, in particular, processes of controlled coherent inertial nuclear fusion, may occur under self-harmonized inertial electromagnetic confinement in the blow-up mode. Shortly, the invention relates to an alleged technical implementation of of a device and method for achieving pycnonuclear fusion. Such fusion reactions are supposed to be achieved within a target made of boron, titanium and lead and using a device as merely sketched in fig. 1 and 2. Up until the present day, and therefore also particularly up to the date of priority of the present application, no such pycnonuclear nuclear fusion apparatus, and corresponding method, has been built and operated so as to produce more electrical output power than electrical input power to such apparatus, as alleged in the application. On the contrary, so far pycnonuclear reactions seem to have been observed in neutron stars or white dwarfs, with only some evidence present from occurring in lab-generated deuterium-tritium plasmas. Therefore, if the present invention indeed allowed to obtain such effect, it would be the first apparatus to ever achieve such a result.

A patent can be granted for an invention which is, inter alia, susceptible of industrial application. This concept is related to the obligation on an applicant to give a sufficient description of the invention allowing a skilled person to put the invention into practice, as required by Article 5 PCT. However, Article 5 PCT makes the amount of information required for a sufficient disclosure of an invention dependent on the actual "nature" of the invention. If the latter lies i.a. in a known technical field, the description need not comprise many specific technical details which would anyway be implicit to a skilled person. However, if the invention is directed to a completely new technical field or, as it would be in the present case, to a major break-through in a per se know field, the disclosure should be detailed enough to prove to a skilled person conversant with mainstream science and technology that the invention is indeed feasible and therefore susceptible of industrial application. This implies, inter alia, the provision of all the data which the skilled person would need to carry out the claimed invention, since such a person, not being able to derive such data from any generally accepted common general knowledge, cannot be expected to implement the teaching of the invention just by trial and error.

In the present case, description and drawings provide a series of technical and scientific information related to such an apparatus and method which are allegedly supposed to allow the generation of more output electrical power than input electrical power (i.e.: electrical power surplus) via the mechanism of pycnonuclear fusion, which must be obtained under certain specific operating conditions. However, the description does not provide any clear and exhaustive technical teaching of what these specific operating conditions are, how they are to be attained and it is not supported by neither any experimental evidence demonstrating the effective obtention of the alleged electrical power surplus output, nor any further independent counter-experiment demonstrating its reproducibility.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 203

Therefore, since the description neither provides for the missing evidence mentioned above, nor it discloses at least one specific operating condition for indeed obtaining such an electrical power surplus, the application is not disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 5 and Rule 5.1(a)(v) PCT).
Because of what reported above, the present application fails to such an extent to comply with the PCT, that it is impossible to carry out a meaningful search regarding the state of the art for all the subject-matter claimed.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.3), should the problems which led to the Article 17(2) PCT declaration be overcome.