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(54) **PRESSURIZED ELECTRO-HYDRAULIC PROCESSING MEANS**

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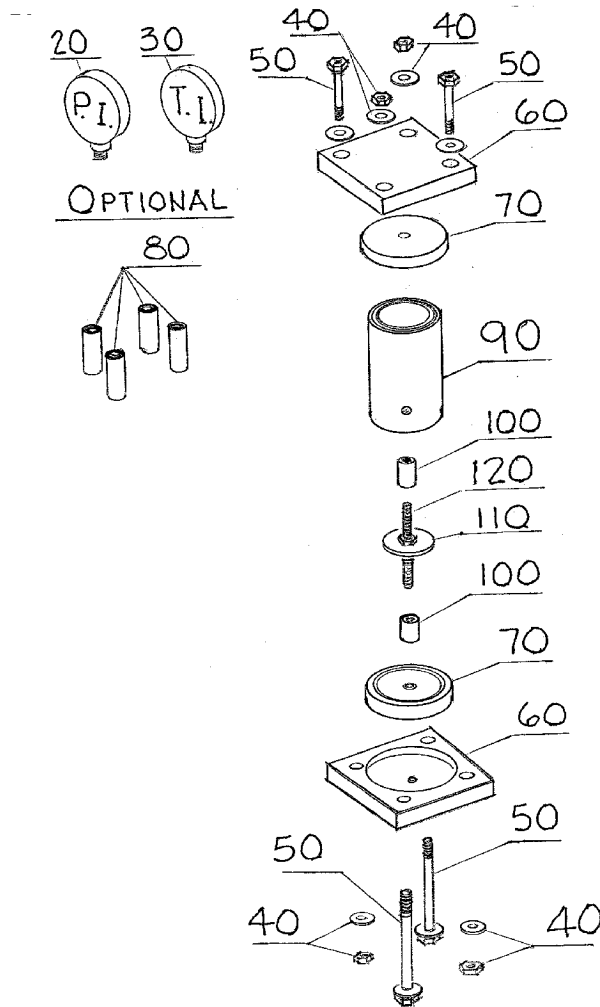
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(57) **ABSTRACT**

A pressurized electrochemical bulk-process method & apparatus, adapted to real-time tracking and adjustment of electro-hydraulic parameters, comprising a high-pressure reaction chamber of the type of a horizontal cylindrical electrolytic cell, whose zirconium walls constitute one electrode in contact with an electrolytic solvent containing the target material to be processed. The other electrode is a thin vertical zirconium disk partially submerged in the electrolyte, which fills less than half of the chamber. Because the electrolyte's resistance is not constant, the current cannot be controlled merely by adjusting the voltage in the 60-cycle AC current; instead, the current amperage must be monitored in real time and the voltage either lowered in response to sharp amperage increases in order to keep the cell's temperature (and hence its pressure) below the safety limits at which the disk-shaped Teflon end-gaskets sealing the cylinder's ends will rupture, or else increased, during normal operation, to compensate for decreases in current caused by various reactions occurring in the electrolyte.



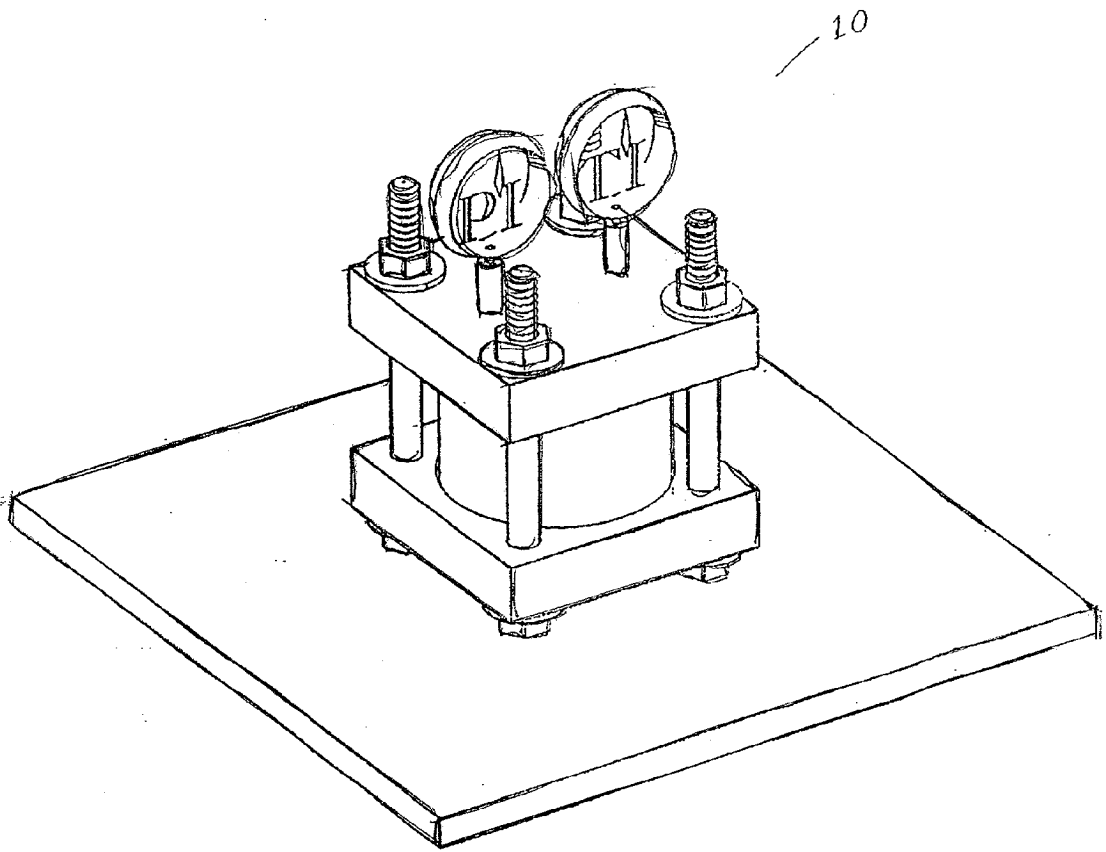


FIGURE 1

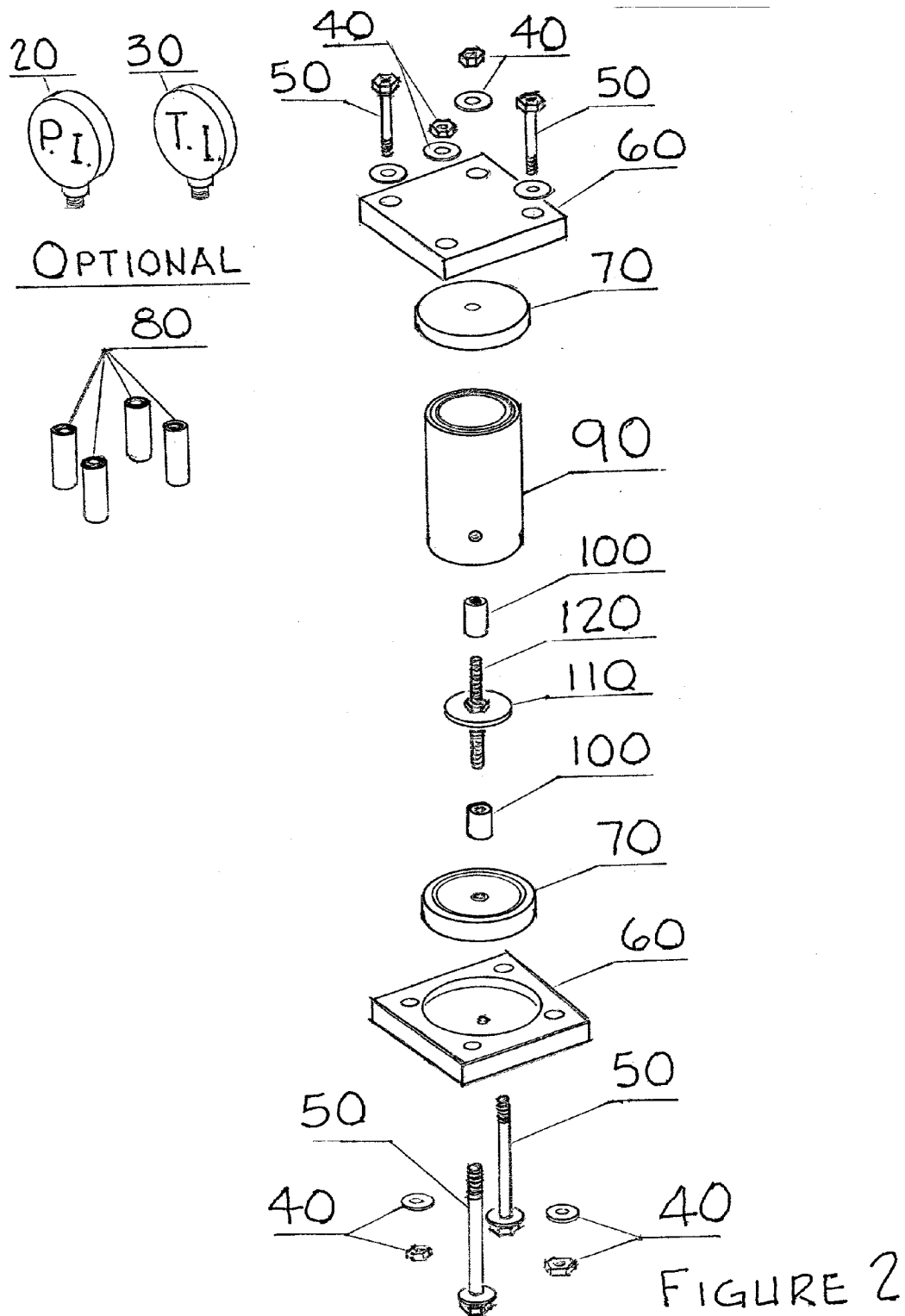


FIGURE 2

PRESSURIZED ELECTRO-HYDRAULIC PROCESSING MEANS

FIELD OF THE INVENTION

[0001] This invention relates to bulk-process electro-hydraulic operations performed by relatively low-energy electrochemical means.

BACKGROUND OF THE INVENTION

[0002] During ancient and medieval times much effort based upon magical or pre-rational thinking, was devoted to the quest for reliable means of transmuting one chemical element into another; the fabled "philosopher's stone" of myth and legend was supposed to enable its possessor to transmute base metals into precious metals, as, e.g. to transmute lead or mercury into gold. While this quest led to the empirical discovery of many of the facts upon which modern or scientific chemistry is based, it was conducted prior to the advent of means for conduction of measurements and sufficiently repeatable "laws of physics" to deduce that "indivisible" particles of matter, or atoms, are not mere speculations of Greek philosophy (using Aristotle's logical Law of the Excluded Middle, upon which all of modern science is based, it is self-evident that matter is either indefinitely divisible or it is not), but in fact constitute demonstrably real building blocks of which matter is composed. When asked what knowledge he would choose to transmit to the survivors of a hypothetical catastrophic annihilation of nearly all of the human race, the late physics Nobel Laureate Richard Feynman said that the single message upon which a technologically advanced civilization could be rebuilt was the information that "atoms exist." When in the late nineteenth and early twentieth century negatively-charged electrons and much heavier positively-charged nuclei were discovered, the supposed "indivisibility" of atoms required a Paradigm Shift, but one which led to the recognition that each chemical element could be distinguished from any other, as Mendeleyev's Periodic Table of the Elements, not by chemical and physical properties, but by simply counting the number of protons in the respective nuclei. This led to a vastly deeper understanding of matter, including the mathematical discipline of Quantum Mechanics, by means of which the chemical properties of atoms and their combinations into molecules may be predicted successfully from first-principles laws of physics. The discovery of spontaneous radioactive decay showed that elemental identity was not immutable, but might occur spontaneously for no obvious reason. Later high-energy-particle experiments showed that one element could be transmuted into another by bombardment with sufficiently high-energy particles (such as protons, deuterons, alpha-particles and the like). It soon became an article of faith among physicists that no macroscopic bulk process (such as provided by heat, pressure or chemical reactions) could affect the nucleus of an atom; radiometric dating methods (which in the case of such short-term methods as radiocarbon dating can be independently calibrated by tree-ring dating and correlation with recorded historical epochs) are based squarely upon this dogma.

[0003] Unfortunately, this "central dogma of modern nuclear physics" has during the twentieth century been proved repeatedly to have been fundamentally mistaken. Modern chemistry professors have transmuted mercury into

gold by utilizing the medieval formula of boiling mercury in gunpowder, as published in such peer-reviewed archival publications as the Journal of New Energy (JONE). Moreover the peer-reviewed archival Journal of Fusion Technology, published by the American Nuclear Society, has printed papers reporting that various low-energy electrochemical processes (such as are utilized when cathodes of palladium or nickel are loaded with isotopes of hydrogen and subjected to relatively low energy stimuli) have led to microscopic but detachable amounts of "anomalous transmutation" in contradiction to the above-quoted central dogma. Recently the two hundred attendees at the last few meetings of the ICCF-n (International Conference on Cold Fusion), such as ICCF-6, ICCF-7, ICCF-8 have been apprised of the new subjects of LINC (Lattice-Induced Chemistry), to use the terminology of Dr. Scott Chubb and Dr. Talbott Chubb of the Naval Research Laboratory (NRL), and of LENT (Low Energy Nuclear Transmutation), to use the terminology by which the present inventor disclosed operable but sub-optimal predecessors of the present process in infinite Energy magazine and the New Energy News (NEN) newsletter and on the Internet at the URL of <http://web.gcis.net/cincyqrq> (after having previously filed an enabling disclosure as U.S. Provisional Patent Application No. 60/052,077, filed Jul. 25, 1997, herein incorporated by reference).

[0004] Furthermore, Texas A&M University Distinguished Professor of Chemistry, Dr. John Bockris, has organized and convened two international conferences specifically limited to the subject of Low-Energy Nuclear Reactions (LENR), held respectively at TAMU on Jun. 19, 1995 and at College Station, Tex. Sept. 13-14, 1996, the complete Proceedings of each of which has been published in JONE, Vol. 1, No.1 (January 1996) and Vol.1, No.3 (Fall 1996.)

[0005] Finally, when the present inventor supplied a working model of the present invention to the leading nuclear physics laboratory in Italy for independent testing, a 7-author paper was published [F. Celani, M. Achilli, A. Battaglia, C. Cattaneo, G. Buzzanca, P. G. Sona, A. Mancini, "Preliminary Results with 'Cincinnati Group' Cell of Thorium 'Transmutation' Under 50 Hz AC Excitation," (ICCF-7) NEN, vol. 6, no. 2 (1998), pp. 17-18.] which reported that a "complete chemical balance" of the before-process and after-processing contents of the cell was obtained by both radiometric measurements and mass-spectroscopy, in which radioactive thorium was replaced by stable elements such as copper, titanium, etc. and in which the possibility of error by contamination was precluded by anomalous isotopic-abundance-ratios of the end-product copper (which was radically discrepant from that of natural copper).

[0006] The historical importance of the present invention was subsequently documented when the present inventor was invited to present a paper at a Special Session of the American Nuclear Society's November 12-16 meeting in Washington, D.C. devoted solely to the subjects of "Low Energy Nuclear Reactions (LENR) and Cold Fusion (CF)" at which 22 papers, by mostly highly reputable scientists and engineers, on LENR & CF were presented (cf. pages 355-379 of ANS Transactions, vol. 83). In the present inventor's paper ["Theoretical and Experimental Results Regarding LENR/CF," pages 355-356, loc. cit.] data was given regarding three different tests in which the percentage of transmutation of radioactive thorium into stable elements achieved

by different I-V-T [current/voltage/time] protocols was, respectively 23%, 50% and 74.6% while the energy expended during processing was, respectively, in Watt-hours, 0.6535 Wh, 32.5 Wh, and 74.6 Wh. This gives a nearly perfect straight-line correlation! In fact, if η denotes percentage of transmutation achieved, and E denotes processing energy expended (obtained by numerically integrating the product of current I and voltage V against time T for the duration of processing) then

$$\eta = (0.8105) \cdot E + 22.888, \quad (0.65 < E < 0.75)$$

[0007] As the final “nail in the coffin” of skepticism regarding the reality of LENR (including CF) it should be noted that in February, 2002 the US Naval Research Laboratory (NRL) released a 299-page, 6-author report [NRL TECHNICAL REPORT 1862, February 2002, Thermal and Nuclear Aspects of the Pd/D20 System (in two volumes)] which not only states that world-wide replication of the CF phenomenon renders its reality beyond doubt but states explicitly that: “We do not know if Cold Fusion will be the answer to future energy needs, but we do know the existence of the Cold Fusion phenomenon through repeated observations by scientists throughout the world. It is time that this phenomenon be investigated so that we can reap whatever benefits accrue from additional scientific understanding. It is time for government funding organizations to invest in this research.”

[0008] The present inventor has accepted the suggestion of Dr. Hal Fox (founder of the Fusion Information Center in Salt Lake City, Utah and editor of the aforesaid JONE & NEN periodicals) that one of the most pressing unsolved technological needs of mankind is the problem of disposal of high-level radioactive waste. Congress has mandated that 88,000 tons of this material must be kept isolated from all animal life for at least 100,000 years (one thousand centuries!); the present plan involves long-term geological storage of such radionuclides at a predicted cost of \$1,500/kilogram PER YEAR (not for a few decades, but for millennia!).

[0009] Accordingly there has been an urgent need for alternative, less expensive means of Radwaste Remediation (RR). The present invention has been proved by internationally published independent testing capable of transmuting bulk quantities of high levels of radioactive wastes at energy cost (e.g. electric power at an assumed 10 cents per kilowatt-hour) an entire order of magnitude lower than the preceding figure, which must be multiplied by hundreds or thousands during the millennia of geological storage, whereas the presently disclosed process need only be performed a single time!

[0010] Also there has been a need for an aneutronic process for RR. Furthermore, there has been need for a safe and cost-effective process for RR whose end-products comprise useful (and non-radioactive or stable) materials whose economic value would offset the processing cost of RR.

[0011] Finally there has been need for a safe process for producing rare materials by transmutation of common elements, as in the “dial-an-element” embodiment of the present process, which is the obvious next step in commercial exploitation of the novel principles disclosed herein.

SUMMARY OF THE INVENTION

[0012] In accordance with the principles of the present invention, there is provided an electrochemical bulk-process

method & apparatus for electro-nuclear conversion of at least one selected chemical element, in macroscopic amounts, into bulk amounts of at least one other species of chemical element not previously present, by utilization of a relatively low-energy aneutronic electrochemical process, comprising a high-pressure reaction chamber of the type of a horizontal cylindrical electrolytic cell, whose zirconium walls constitute one electrode in contact with an electrolytic solvent containing the target material to be processed. The other electrode is a thin vertical zirconium disk partially submerged in the electrolyte, which fills less than half of the chamber. Because the electrolyte's resistance is not constant, the current cannot be controlled merely by adjusting the voltage in the 60-cycle AC current; instead, the current amperage must be monitored in real time and the voltage either lowered in response to sharp amperage increases in order to keep the cell's temperature (and hence its pressure) below the safety limits at which the disk-shaped Teflon end-gaskets sealing the cylinder's ends will rupture, or else increased in response to diminishing current flow as a result of the various reactions that occur during processing.

[0013] In accordance with a further aspect of the invention, the amount of transmutation achieved may be estimated in real time by monitoring the integral of the product of the input voltages and amperages in order to track the total amount of energy used; it has been demonstrated empirically [ANS Trans., vol. 83, pp. 355-56] that the degree of transmutation achieved, over a wide parameter range, is close to a linear function of the amount of energy used. Hence records of previous calibration runs will enable the process to be terminated when the desired degrees of transmutation have been achieved.

[0014] Similarly, systematic tests over a large domain of target materials and operating protocols will enable an empirical database to be constructed from which the presently disclosed invention can be operated in a “dial-an-element” mode, in which selected materials may be transmuted into other materials virtually at will.

[0015] Other objects, features and advantages will become apparent from a consideration of the following detailed description and from the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a perspective drawing of an assembled LENT-1 electro-hydraulic reactor placed vertically on one end, although it is operated in a horizontal position (not shown); and

[0017] FIG. 2 is an exploded drawing of the unassembled components from which the assembled LENT-1 electro-hydraulic reactor depicted in FIG. 1 may be assembled.

DETAILED DESCRIPTION OF PRESENTLY PREFERRED EMBODIMENT

[0018] Referring more particularly to the drawings, FIG. 1 shows an upended LENT-1 Electro-hydraulic reactor 10 rotated through ninety degrees from the horizontal position in which it is partly filled with an electrolytic solution and operated as an electrochemical apparatus of the well-known electrolysis type.

[0019] FIG. 2 shows the components of which reactor 10 are assembled. Optional pressure gauge 20 is shown

attached to one end, although other positions have been used successfully. Likewise the temperature gauge **30** need not be positioned as shown. Nuts **40** are employed to hold heavy-duty stainless bolts **50** in such a manner as to attach heavy-duty stainless-steel end plates **60** in spaced-apart tension with each other, thereby clamping non-conductive (e.g. machined Teflon) gaskets **70** tightly against the ends of cylindrical outer electrode **90**.

[0020] Current-carrying threaded metallic rod **120** is insulated from the liquid contents of reactor **10** by means of insulating sleeves **100**, which permit electrical currents to reach central washer electrode **110**. (**110** is screwed onto **120**. Two zirconium nuts are used on end plates **60** to ensure proper electrical contact. Small springs (**115**) not shown are placed between the ends of the rod **120** and end plates **60** to improve conductivity.

[0021] Insulating sleeves **100** permit electrical current to be carried to washer-electrode **110** through metallic rod **120**, which is insulated so that the liquid contents of reactor **10** cannot contact current-carrying rod **120**.

[0022] In the presently preferred embodiment of the present invention, both electrodes **90** and **110** are composed of pure zirconium, and the non-conductive components **70**, **80** and **100** are composed of Teflon. The presently preferred temperature range of the electrolyte is between 60 degrees and 300 degrees Fahrenheit; the voltage range is between 40 volts and 200 volts; the current range is between zero and 10 amperes. Pressure is not a controlled parameter. In demonstrations of the reality of radwaste remediation a solution of thorium was used that consisted of 1 gram per 100 cubic centimeters.

[0023] The mode of operation of reactor **10** and associated voltage/amperage/temperature or I-V-T protocols have been published in both archival and semi-popular journals and are by now sufficiently well-known that the references cited in the accompanying Information Disclosure Statement (IDS) are more than sufficient to establish that the mode of I-V-T operation of such an electro-hydraulic reactor is already well known to those of ordinary skill in the art and therefore need not be further detailed herein (other than to incorporate said publications by reference).

[0024] In conclusion, it is to be understood that the foregoing detailed description, and the accompanying drawings, relate to illustrative cases of the presently preferred embodiment of the invention. However, various changes may be made without departing from the spirit and the scope of the invention. Thus, by way of example and not of limitation, the sodium silicate salt used to render the pure water solvent into an electrolyte may be replaced by other salts (such as sodium metasilicate). Other inert electrolytes used include lithium sulfate, sulfuric acid, and acetic acid.

[0025] Furthermore, it is possible to use titanium electrodes instead of zirconium electrodes. In addition, the parts need not have the precise configuration described herein above, but may have alternative arrangements. Further, instead of the external structural parts being made of stainless steel, they may in many cases be formed of any material having adequate tensile strength to hold the end-gaskets sealed to the reaction chamber when they are subject to the internal expansive pressures anticipated from the particular processes to be operated.

[0026] It is understood that the order in which the steps of a method claim are presented is not necessarily required in the practice of the invention; for example, the target materials may be introduced into the solvent before the target-carrying solvent is introduced into the vessel, or, alternatively, the solvent may be introduced into the vessel and then the target materials may be introduced into the solvent after it is already in the vessel. Such obvious variations will be well understood by those of ordinary skill in the art and therefore need not be claimed explicitly in both sequential orders as if one statement of an acceptable sequential order were inadequate to imply the acceptability of the reverse order.

[0027] In the following claims, the word liquid has its normal meaning, while the word fluid is used in a more general manner (as in works on the Physics of Fluids) to refer to a liquid, a gas, a plasma, or any combination thereof.

[0028] Accordingly, it is to be understood that the detailed description and the accompanying drawings as set forth herein above are not intended to limit the breadth of the present invention, which should be inferred only from the following claims and their appropriately construed legal equivalents, as well as obvious variations thereof, rather than from the example(s) given.

What is claimed is:

1. An apparatus for aneutronic bulk-process transmutation of at least one selected chemical element, in macroscopic amounts, into bulk amounts of at least one other species of chemical element not previously present, by utilization of a relatively low-energy electrochemical process, comprising:

- (a) a horizontally-positioned cylindrical reaction chamber comprised of a length of zirconium piping.
- (b) disk-shaped Teflon gaskets adapted to seal both ends of said chamber;
- (c) an insulated zirconium rod-shaped conductor, centrally penetrating said gaskets and positioned axially along the central axis of rotational symmetry of said piping and adapted to carry external electrical current to both
- (d) a central relatively thin vertical disk-shaped zirconium electrode positioned perpendicularly to said axis of symmetry and extending its circular edges to within a pre-selected small distance of the cylindrical walls of said piping, as well as
- (e) thick stainless-steel end-plates, positioned apart but held in contractive tension by strong stainless steel bolts parallel to said axis, adapted to hold said gaskets firmly against the punctured-disk-shaped ends of said piping, with sufficient tensile strength to convert the apparatus into a high-pressure processing electrolytic cell when an electrolytic solvent liquid containing target materials for processing is introduced into said cylindrical reaction chamber in sufficient quantity for said liquid to be in contact with at least the lower portion of said vertical disk electrode as well as the lower portion of the containing cylindrically shaped wall-electrode;

- (f) a high-pressure port by means of which a selected amount of said liquid may be introduced into said chamber and sealed therein prior to electrolytic processing;
- (g) externally visible thermometric monitoring means permitting said chamber's temperature to be monitored visually during processing;
- (h) external 60-cycle alternating current supply means,
- (i) means for electrically connecting said disk-electrode and said chamber walls through said electrolytic fluid so as to constitute an electrolytic cell; and
- (j) means for real-time monitoring of both current amperage and voltage flowing through said electrolytic cell during processing; and
- (k) means allowing an operator to make real-time adjustments of said voltage in order to keep said amperage from raising said liquid's temperature to a point wherein the resultant fluid pressure poses a risk of rupture to said gaskets while simultaneously adapting to current decreases caused by variations in the electrolyte's resistance arising from reactions of the material being processed.
2. An apparatus for aneutronic bulk-process transmutation of at least one selected chemical element, in macroscopic amounts, into bulk amounts of at least one other species of chemical element not previously present, by utilization of a relatively low energy electrochemical process comprising:
- (a) a selected bulk amount of at least one target element of a selected chemical identity to be transmuted;
- (b) a thermally stable vessel selected from the class comprising leak-proof vessels and fluid pressure-tight vessels, in which to operate the process at temperatures higher than room-temperature;
- (c) a selected bulk quantity of a pre-selected liquid solvent into which said target element is dissolved;
- (d) at least one soluble material added to said target-carrying solvent which converts said target-carrying solvent into an electrically conductive electrolytic
- (e) an electrolytic cell comprised of said vessel containing said target carrying electrolytic solvent;
- (f) at least two electrodes selected from the group comprising metals and solid conductive material;
- (g) means for positioning at least one of said electrodes at least partially submerged in said target-carrying electrolytic solvent;
- (h) means for positioning at least one other of said electrodes in sufficiently close proximity to said vessel that a closed-loop electrical current may be established which runs through at least one of each said electrodes, and between them in said electrolyte, when energized by an external source of electrical power;
- (i) an external source of electrical power selected from the class comprising direct current, alternating current and pulsed direct current;
- (j) means for controlling in real time the salient power-conditioning characteristics of said power sources as regards features selected from the group comprising voltage, amperage, AC frequency, and pulse-repetition rate, in order to operate said combination of vessel, electrolytic solvent, dissolved target material, electrodes and power source as a closed-loop electrolytic cell, together with
- (k) instrumentation for real-time monitoring of at least one of said solvent's fluid characteristics, selected from the group comprising fluid temperature and fluid pressure;
- (l) means for adjusting said power-conditioning characteristics in real time in order to control said fluid characteristics in real time by means of a control technology selected from the group comprising human operated manual control, automatic feedback control and pre-programmed command control;
- (m) timing means for operating said electrolytic cell during a sufficiently long epoch that at least a macroscopic amount of said target element is transmuted in bulk amounts into at least one other element not previously present, and
- (n) safety means for exercising said control technology in such a manner as to maintain the microphysical energy levels of said cell's materials below the levels at which detectable neutrons might be produced and below the levels at which detectable ionizing radiation might be produced.
3. The apparatus of claim 2 in which said vessel is fluid-pressure-tight and adapted to contain pressures greater than atmospheric without rupturing.
4. The apparatus of claim 2 in which said soluble material coincides with said target material.
5. The apparatus of claim 2 in which said target material is compounded with said soluble material so that dissolving this compound in said solvent material creates a target-carrying electrolytic solvent.
6. The apparatus of claim 2 in which said instrumentation comprises means for measuring the temperature of said electrolytic solvent in real time.
7. The apparatus of claim 2 in which said control technology comprises computer controlled automatic feedback control means.
8. The apparatus of claim 2 in which said control technology comprises computer-controlled preprogrammed command control means.
9. The apparatus of claim 2 in which said timing means comprises means for real time monitoring of the amount of said target material's transmutation together with control means for termination of the operation of said apparatus when a pre-selected degree of transmutation has been achieved.
10. The apparatus of claim 2 in which said timing means comprises means for monitoring of the amount of electrical energy used, by means of which an indirect determination of the amount of transmutation achieved can be estimated in real time by means of comparison with records of previously monitored processes of comparable type.
11. The apparatus of claim 2 in which said safety means comprises instrumentation for detection of radiation selected from the group comprising neutron fluxes and ionizing radiation fluxes, together with automatic negative feedback control means for immediately decreasing the power input to the process if such a flux be detected.

12. An aneutronic bulk-process method for transmuting at least one selected chemical element, in macroscopic amounts, into bulk amounts of at least one other species of chemical element not previously present, by utilization of a relatively low-energy electrochemical process, comprising the steps of:

- (a) selecting a bulk amount and a chemical identity of at least one target element to be transmuted;
- (b) providing a thermally stable vessel selected from the class comprising leak proof vessels and fluid-pressure-tight vessels, in which to operate the process at temperatures higher than room temperature;
- (c) dissolving said target element in a selected bulk quantity of a pre-selected liquid solvent;
- (d) adding to said solvent at least one soluble material which converts said target carrying solvent into an electrically conductive electrolyte;
- (e) introducing said target carrying electrolytic solvent into said vessel,
- (f) selecting at least two electrodes from the group comprising metals and solid conductive materials;
- (g) positioning at least one of said electrodes at least partially submerged in said target-carrying electrolytic solvent;
- (h) positioning at least one other of said electrodes in sufficiently close proximity to said vessel that a closed-loop electrical current may be established which runs through at least one each of said electrodes, and between them in said electrolyte, when energized by an external source of electrical power;
- (i) providing an external source of electrical power selected from the class comprising direct current, alternating current and pulsed direct current;
- (j) controlling in real time the salient power-conditioning characteristics of said power source as regards features selected from the group comprising voltage, amperage, AC frequency, and pulse-repetition rate, in order to operate said combination of vessel, electrolytic solvent, dissolved target material, electrodes and power source as a closed-loop electrolytic cell, while,
- (k) providing instrumentation for real-time monitoring of at least one of said solvent's fluid characteristics, selected from the group comprising fluid temperature and fluid pressure;
- (l) adjusting said power conditioning characteristics in real time in order to control said fluid characteristic in real time by means of a control technology selected from the group comprising human-operated manual control, automatic feedback control, and pre-programmed command control; and

(m) operating said electrolytic cell during a sufficiently long epoch that at least a macroscopic amount of said target element is transmuted in bulk amounts into at least one other element not previously present, while

(n) safely exercising said control technology in such a manner as to maintain the microphysical energy levels of said cell's materials below the levels at which detectable neutrons might be produced and below the levels at which detectable ionizing radiation might be produced.

13. The method of claim 12 comprising the additional step of selecting said vessel to be fluid-pressure-tight and capable of containing pressures greater than atmospheric without rupturing.

14. The method of claim 12 comprising the additional step of selecting said soluble material to coincide with said target material.

15. The method of claim 12 comprising the additional step of compounding said target material with said soluble material and dissolving this compound in said solvent material to create a target-carrying electrolytic solvent.

16. The method of claim 12 comprising the additional step of selecting said instrumentation to comprise means for measuring the temperature of said electrolytic solvent in real time.

17. The method of claim 12 comprising the additional step of selecting said control technology to comprise computer-controlled automatic feedback control means.

18. The method of claim 12 comprising the additional step of selecting said control technology to comprise computer-controlled preprogrammed command-control means.

19. The method of claim 12 comprising the additional step of selecting said timing means to comprise means for real-time monitoring of the amount of said target material's transmutation together with control means for termination of the operation of the process when a pre-selected amount of transmutation has been achieved.

20. The method of claim 12 comprising the additional step of selecting said timing means to comprise means for monitoring of the amount of electrical energy used, by means of which an indirect determination of the amount of transmutation achieved can be estimated in real time by means of comparison with records of previously monitored processes of comparable type.

21. The method of claim 12 comprising the additional step of selecting said safe control manner to comprise use of instrumentation for detection of radiation selected from the group comprising neutron fluxes and ionizing radiation fluxes, together with automatic negative feedback control means for immediately decreasing the power input to the process if such a flux be detected.

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