**Nuclear battery**

**ABSTRACT**

 The idea of nuclear battery was introduced in the beginning of 1950, and was patented on Mar 3, 1959 to Tracer lab. Even though the idea was given more than 30 years before no significant progress was made on the subject because the yield was very less.

 Unlike conventional nuclear power generating devices, these power cells does not rely on a nuclear reaction or chemical process and does not produce radioactive waste products. The nuclear battery technology is geared toward applications where power is needed in inaccessible places or under extreme conditions.

 The researchers envision its uses in pacemakers and other medical devices that would otherwise require surgery to repair or replace. Additionally, deep-space probes and deep-sea sensors, which are beyond the reach of repair, would benefit from such technology.

 In the near future this technology is said to make its way into commonly used day to day products like mobile and laptops and even the smallest of the devices used at home. Surely these are the batteries of the near future.

1. **INTRODUCTION**

 A burgeoning need exists today for small, compact, reliable, lightweight and self-contained rugged power supplies to provide electrical power in such applications as electric automobiles, homes, industrial, agricultural, recreational, remote monitoring systems, spacecraft and deep-sea probes. Radar, advanced communications satellites and, especially, high-technology weapons platforms will require much larger power sources than today's space power systems can deliver. For the very high power applications, nuclear reactors appear to be the answer. However, for the intermediate power range, 10 to 100 kilowatts (KW), the nuclear reactor presents formidable technical problems. Because of the short and unpredictable lifespan of chemical batteries, however, regular replacements would be required to keep these devices humming.

 Also, enough chemical fuel to provide 100 KW for any significant period of time would be too heavy and bulky for practical use. Fuel cells and solar cells require little maintenance, but the former are too expensive for such modest, low-power applications, and the latter need plenty of sun. Thus the demand to exploit the radioactive energy has become inevitable high. Several methods have been developed for conversion of radioactive energy released during the decay of natural radioactive elements into electrical energy.

 A grapefruit-sized radioisotope thermo-electric generator that utilized the heat produced from alpha particles emitted as plutonium-238 decays was developed during the early 1950's. Since then the nuclear power has taken a significant consideration in the energy source of future. Also, with the advancement of the technology the requirement for lasting energy sources has been increased to a great extent.

 The solution to the long term energy source is, of course, the nuclear batteries with a lifespan measured in decades and has the potential to be nearly 200 times more efficient than the currently used ordinary batteries. These incredibly long-lasting batteries are still in the theoretical and developmental stage of existence, but they promise to provide clean, safe, almost endless energy.

1. **DIRECT CHARGING GENERATORS**

 In this type, the primary generator consists of a high-Q LC tank circuit. The energy imparted to radioactive decay products during the spontaneous disintegrations of radioactive material is utilized to sustain and amplify the oscillations in the high-Q LC tank circuit.

 The circuit inductance comprises a coil wound on a core composed of radioactive nuclides connected in series with the primary winding of a power transformer. The core is fabricated from a mixture of three radioactive materials which decay primarily by alpha emission and provides a greater flux of radioactive decay products than the equivalent amount of a single radioactive nuclide.



Fig: 3schematic diagram of an LC equivalent resonant circuit

Equitant circuit of the direct charging generator is as shown in the figure 3. An LCR circuit 1 is comprised of a capacitor 3, inductor 5, transformer T primary winding 9 and resistance 11 connected in series. It is assumed that the electrical conductors connecting the various circuit elements and forming the inductor 5 and primary winding 9 are perfect conductors; i.e., no DC resistance. Resistor 11 is a lump resistance equivalent to the total DC resistance of the actual circuit components and conductors.

The inductor 5 is wound on a core 7 which is composed of a mixture of radioactive elements decaying primarily by alpha particle emission. When current flows in electrical circuit energy is dissipated or lost in the form of heat. Thus, when oscillations are induced in an LCR circuit, the oscillations will gradually damp out due to the loss of energy in the circuit unless energy is continuously added to the circuit to sustain the oscillations.

 In the LCR circuit shown in Figure 3, a portion of the energy imparted to the decay products, such as alpha particles, during the radioactive decay of the materials making up inductor core 7 is introduced into the circuit 1 when the decay products are absorbed by the conductor which forms inductor 5. Once oscillations have been induced in the LCR circuit 1, the energy absorbed by inductor 5 from the radioactive decay of the core 7 materials will sustain the oscillations as long as the amount of energy absorbed is equal to the amount of energy dissipated in the ohmic resistance of the circuit 1.

 If the absorbed energy is greater than the amount of energy lost through ohmic heating, the oscillations will be amplified. This excess energy can be delivered to a load 17 connected across the transformer T secondary winding 13. The processes involved in the conversion of the energy released by the spontaneous disintegration of a radioactive material into electrical energy are numerous and complex. Materials that are naturally radioactive decay by the emission of either an alpha particle or a beta particle, and gamma rays may accompany either process. Radioactive materials that decay primarily by alpha particle emission are preferred as the inductor core 7 materials.

 Alpha particles are emitted at very high speeds, in the order of 1.6X107 meters per second (m/s), and, consequently, have very high kinetic energy. Alpha particles emitted when radium, for example, decays are found to consist of two groups, those with a kinetic energy of 48.79X105 electron volts (eV) and those having energy of 46.95X105 eV.

This kinetic energy must be dissipated when the alpha particles are absorbed by the conductor forming inductor 5. During the absorption process, each alpha particle will collide with one or more atoms in the conductor knocking electrons from their orbits and imparting some kinetic energy to the electrons.

 This results in increased numbers of conduction electrons in the conductor thereby increasing its conductivity. Since the alpha particle is a positively charged ion, while the alpha particle is moving it will have an associated magnetic field. When the alpha particle is stopped by the conductor, the magnetic field will collapse thereby inducing a pulse of current in the conductor producing a net increase in the current flowing in the circuit 1.

 Also, there will be additional electrons stripped from orbit due to ionization produced by the positively charged alpha particles.



Fig: 4 wiring diagram of a constructed nuclear battery

 The nuclear battery is constructed in a cylindrical configuration. Inductor 5 is constructed of copper wire wound in a single layer around the radioactive core 7. Decay products, such as alpha particles, are emitted radially outward from the core 7 as indicated by arrows 2 to be absorbed by the copper conductor forming inductor 5. Eight transformers 15 are arranged in a circular pattern to form a cylinder concentric with and surrounding inductor 5.

 The transformers 15 have primary windings 9a-9h connected in series which are then connected in series with inductor 5 and capacitor 3 to form an LCR circuit. The central core 7, inductor 5 and the eight transformers 15 are positioned within a cylindrical-shaped container 19. Copper wire is wound in a single layer on the outside wall and the inside wall of cylinder 19 to form windings 23 and 21 respectively. The transformers 15 secondary windings 13a-13h and windings 21 and 23 are connected in series to output terminals 25 and 27. The configuration of inductor 5 is designed to insure maximum irradiation of the copper conductor by the radioactive core source 7. The cylindrical configuration of the power transformer ensures maximum transformer efficiency with minimum magnetic flux leakage.

An Optoelectric nuclear battery has also been proposed by researchers of the Kurchatov Institute in Moscow. A beta-emitter such as technetium-99 orstrontium-90 is suspended in a gas or liquid containing luminescent gas molecules of the exciter type, constituting “dust plasma”. This permits a nearly lossless emission of beta electrons from the emitting dust particles for excitation of the gases whose excimer line is selected for the conversion of the radioactivity into a surrounding photovoltaic layer such that a comparably light weight low pressure, high efficiency battery can be realized.

 These nuclides are low cost radioactive waste of nuclear power reactors. The diameter of the dust particles is so small (few micrometers) that the electrons from the beta decay leave the dust particles nearly without loss.

 The surrounding weakly ionized plasma consists of gases or gas mixtures (e.g. krypton, argon, xenon) with excimer lines, such that a considerable amount of the energy of the beta electrons is converted into this light. The surrounding walls contain photovoltaic layers with wide forbidden zones as egg. Diamond which converts the optical energy generated from the radiation into electric energy.

 The battery would consist of an excimer of argon, xenon, or krypton (or a mixture of two or three of them) in a pressure vessel with an internal mirrored surface, finely-ground radioisotope, and an intermittent ultrasonic stirrer, illuminating a photocell with a band gap tuned for the excimer.

 When the electrons of the beta active nuclides (e.g. krypton-85 or argon-39) are excited, in the narrow excimer band at a minimum of thermal losses, the radiations so obtained is converted into electricity in a high band gap photovoltaic layer (e.g. in p-n diamond) very efficiently. The electric power per weight compared with existing radionuclide batteries can then be increased by a factor 10 to 50 and more. If the pressure-vessel is carbon fiber/epoxy the weight to power ratio is said to be comparable to an air-breathing engine with fuel tanks.

 The advantage of this design is that precision electrode assemblies are not needed, and most beta particles escape the finely-divided bulk material to contribute to the battery's net power.

 The disadvantage consists in the high price of the radionuclide and in the high pressure of up to 10 MPa (100 bar) and more for the gas that requires an expensive and heavy container.



Fig 5: Optoelectric Generator

**REFERENCES**

 1.“*Power from Radioisotopes*,” *USAEC, Division of Technical Information*"*Nuclear and Radiochemistry*", Gerhart Friedlander, Joseph W. Kennedyand Julian Malcolm Miller.

 2."*Particles and Nuclei, An Introduction to the Physical Concepts*", B. Povh, K. Rith, C. Scholz, and F. Zetche.

1. “*The Role of Chemical Power Sources in Modern*
2. *Health Care*”, Curtis F. Holmes.