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NUCLEAR BATTERIES FOR SPACE APPLICATIONS: FROM 1913 TO THE MOON AND BEYOND

Abstract

Nuclear batteries, the solid-state devices that convert energy from radioactive decays in electricity, are autonomous electric power generating systems characterised by long working-life, portability and high stability under extreme environmental conditions. High-performing independent electric power supplies, designed for deep space and planetary missions, have been found to be suitable also for supplying power to medical devices, observation stations and wireless communication systems in isolated terrestrial/undersea locations. The performances of the radioactivity converters working continuously for several years and also decades, make these devices adequate also to charge secondary batteries/capacitors for critical operations. These low-power/long-lasting energy sources have been essential in several space missions (including the early Apollo program, Cassini, Curiosity and Perseverance) but had found applications also in military missions and terrestrial environments where the use of solar or other power generation technologies is challenging or impossible. A 238-Pu powered battery has been used to deliver energy to the rover and the scientific instruments that have been collecting data from Mars for about 14 years. In addition, radioisotope power systems utilising americium-241 as a source of heat have been under development in Europe as part of a European Space Agency (ESA) funded programme since 2009. In view of the more demanding future missions and to enable key ISRU tasks, robust and reliable systems are needed, capable of withstanding the challenging planetary and deep space environment. Taking into consideration the technical advances recently achieved for such appealing stand-alone power supply systems and the perspective of their integration in long-term space programmes, in this paper we review the state-of-the-art of nuclear batteries in terms of both scientific publications and patents. In order to reach this goal, we used specific keywords to analyse patent families and scientific publications for the period 2010-2021, identifying, among others, the global trends, the geographic distribution, top assignees and funding sponsors. As a result, the reported data provide a clear overview of the technologies emerging in the field of nuclear batteries and highlight a significant increase of both scientific literature and patents in the period under examination, particularly when taking into consideration China and the United States.