Betavoltaic Batteries: A Historical Review

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History:

In 1953, Paul Rapport at RCA was the first to describe a betavoltaic device with a SR90-Y90 radioactive source. It yielded an efficiency of 0.2% and degraded quite rapidly due to radiation damage [1]. Several others continued research into betavoltaics [2,3], but the most extensive effort in producing a viable betavoltaic power source appears to have been carried out at Donald W. Douglas Laboratories (DWDL) from 1968 to 1974 under the leadership of Dr. Larry Olsen, one of the authors and member of the City Labs team[4,5]. Pm-147 beta sources were combined with custom designed Si n/p cells to produce nuclear batteries for heart pacemakers. The power sources were referred to as Betacel batteries. The basic approach to battery fabrication involved stacking unidirectional-source/Si-n/p cell units in a series arrangement as depicted in Figure 1A. A picture of a 400 microwatt battery is shown in Figure 1B. Much of the battery volume shown in Figure 1B is due to shielding. The efficiency of these batteries was approximately 4 % based on incident beta flux. Development of bidirectional beta sources was underway when the program ended. Advanced batteries based on bidirectional sources would have exhibited an efficiency of 8 %. The volume of the battery shown in Figure 1 was approximately one cubic inch, or 16 cm^3. Most of the volume was required for shielding the gamma radiation emitted from the Pm-146 contaminant in Pm-147.

(A) (B)

Figure 1. (A) Configuration used for Betacel batteries. (B) Picture of a Betacel battery that produced 400 μW. A large part of the total volume of approximately 1 in^3 was due to shielding.

Thus, the power density of the completed battery was on the order of 0.025 mW/cm^3. DWDL Betacel batteries showed no effects of radiation damage. That is, the power levels decreased in time as expected accounting for the decline in Pm-147 beta flux versus time (i.e. The Betacel power would decline by half every 2.62 years as dictated by Pm-147 half-life).

The Betacel was used to power cardiac pacemakers in over 100 patients during the 1970's, but due to gamma radiation concerns, however, the Lithium battery was able to capture the pacemaker market. Despite the stigma surrounding the earlier work, numerous research groups have continued their attempts

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to commercialize a safe and reliable betavoltaic battery. Subsequent thereto, Dr. Olsen published a betavoltaic review [6] suggesting Tritium as a safe, reliable, and abundant alternative to other radioisotopes. Independently, City Labs also concluded that Tritium would serve well as an excellent candidate for use within a betavoltaic battery design. This conclusion was prompted by Tritium's use within the public domain in Exit signs for school buildings and theaters, wrist-watches, and illuminated gun/rifle sights. These currently fielded applications of Tritium are fueled by somewhat mitigated levels of regulatory compliance criteria as compared to other betavoltaic radio-isotope candidates (e.g. Pm-147, Ni-63).

References:

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