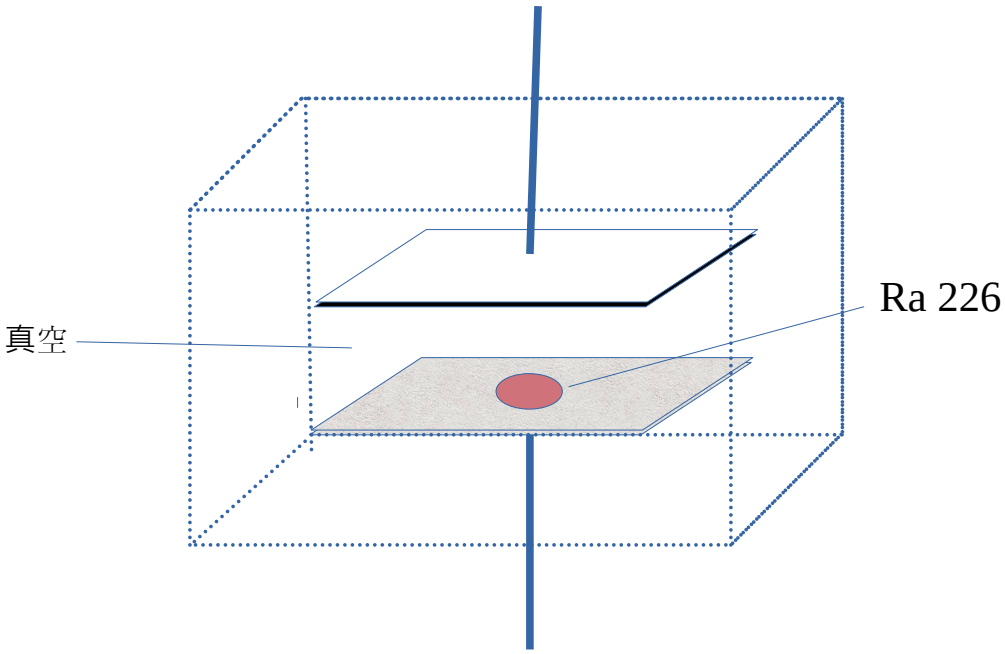

放在真空盒子裏的平行金屬板的其中一塊塗上輻射物。此裝置是最簡單的一個利用輻射而製造的原子能電池（atomic battery）。現有一例。

塗上的輻射物：radium-226

衰變 $^{226}Ra \rightarrow {}^{222}Rn$

方式：α

能量 4.871 MeV

半衰期 1600 年

活性 1 Ci = 3.7×10^{10} Bq

平行金屬板：

尺寸 3 cm × 3 cm

兩板分隔 1 cm

問題：

（i）計算兩平行板的最終電壓。

（ii）計算出現（i）電壓時平行板累積的電荷。

（iii）估算此裝置可提供的穩定電流。

解答：

（i）能量單位 eV 是指當電子橫跨 +1V（去正極）時獲得的能量。在此例，Ra-226 發出的 α 粒子的動能是 4.871 MeV，即是它的動能僅可到達/不到達一個 4.871 MV ÷2 的正電壓（α 帶 2 份正電荷，朝正極去會損耗動能）。

所以，裝置最後的電壓是 4.871 MV ÷ 2 = 2.44 ×10^6 V 。此後，放射源的 α 粒子已無法到達對岸以累積更多正電荷了。

（ii）平行板公式 $V = \frac{Qd}{\varepsilon_o A}$

$$Q = \frac{\varepsilon_o AV}{d}$$

$$Q = \frac{(8.85\times10^{-12})(0.03^2)(2.44\times10^6)}{0.01} = 1.94\times10^{-6}\,\text{C}$$

此電荷由 α 累積而成。每粒 α 攜帶的電荷是 +2 × 1.6 × 10^{-19} C。
裝置用的輻射源的活性 activity 是 3.7 × 10^{10} Bq，此即是每秒衰變的次數。所以，要累積這個 Q 經歷的時間是

$$\frac{1.94\times10^{-6}}{2\times1.6\times10^{-19}}\frac{1}{3.7\times10^{10}} = 164\,s$$

（iii）若把（ii）$Q = 1.94 \times 10^{-6}$ C 一秒清空，那電流是 1.94 μA，但之後電流無以為繼（要 164 s 才可回復）。所以穩定電流只可以是輻射源每秒補充的那數量 i. e.

$$(2 \times 1.6 \times 10^{-19})(3.7 \times 10^{10}) = 1.18 \times 10^{-8}\,\text{A} = 11.8\,\text{nA}$$

這個原子能電池電壓是 2.44 MV，電流 11.8 nA。

Electrostatic conversion [edit]

Energy can be extracted from emitted charged particles when their charge builds up in a conductor, thus creating an electrostatic potential. Without a dissipation mode the voltage can increase up to the energy of the radiated particles, which may range from several kilovolts (for beta radiation) up to megavolts (alpha radiation). The built up electrostatic energy can be turned into usable electricity in one of the following ways.

Direct-charging generator [edit]

A direct-charging generator consists of a capacitor charged by the current of charged particles from a radioactive layer deposited on one of the electrodes. Spacing can be either vacuum or dielectric. Negatively charged beta particles or positively charged alpha particles, positrons or fission fragments may be utilized. Although this form of nuclear-electric generator dates back to 1913, few applications have been found in the past for the extremely low currents and inconveniently high voltages provided by direct-charging generators. Oscillator/transformer systems are employed to reduce the voltages, then rectifiers are used to transform the AC power back to direct current.

English physicist H. G. J. Moseley constructed the first of these. Moseley's apparatus consisted of a glass globe silvered on the inside with a radium emitter mounted on the tip of a wire at the center. The charged particles from the radium created a flow of electricity as they moved quickly from the radium to the inside surface of the sphere. As late as 1945 the Moseley model guided other efforts to build experimental batteries generating electricity from the emissions of radioactive elements.

https://en.wikipedia.org/wiki/Atomic_battery

作者：吳老師 (Chiu-King Ng)

https://ngsir.netfirms.com

http://phy.hk

電郵：feedbackWZ@phy.hk 其中 WZ 是 23 之後的質數