## A Long-Lived Isotope of Yttrium

In samples of strontium bombarded with 16-million-volt deuterons from the Berkeley 60-inch cyclotron in order to produce radioactive strontium for biological investigations, we separated a long-lived (about 100 days) radioactive yttrium having interesting properties. This isotope has been independently observed by L. A. DuBridge and J. Marshall[1] from strontium bombardment with protons. If their assignment is correct it would be $Y^{86}$ produced by a $1d-2n$ reaction from $Sr^{86}$. It emits a penetrating gamma-radiation and practically no beta-radiation harder than 300 kev. No experiment capable of detecting softer beta-rays has yet been done. The absorption curve in Cu, Pb and Fe of yttrium and radium gamma-rays, filtered through 2 cm of lead, are almost identical. E. Segrè and the writer have observed that the yttrium gamma-radiation is capable of producing photo-neutrons in beryllium. The photo-neutrons, slowed in paraffin, were detected by the radioactivity induced in rhodium.

The yield is about 12 milligrams radium equivalent for 1000 microampere hours of 16-million-volt deuterons (about 10 hours of the Berkeley 60-inch cyclotron) when strontium oxide is bombarded, as compared with 6 millicuries of $Sr^{89}$. Since radioactive strontium has been produced in large quantities for therapeutic purposes, an appreciable amount of long-lived yttrium has been made available (about 25 milligrams radium equivalent). Figure 1 shows that this isotope should be suitable for industrial radiography. The upper picture shows an iron clamp partially covered with a piece of iron, two inches thick. The gamma-radiation is sufficiently penetrating so that the clamp appears clearly in both cases, whether it is or is not covered with the iron plate. The lower picture shows an electric motor. Because of its long life and its penetrating gamma-radiation, this radioactive yttrium is, among the artificial radioactive elements known at the present time, the most likely to be substituted for radium, but it must be considered at the present time merely as a by-product of the radio-strontium preparation as it is, as yet, appreciably more expensive than radium for a like dose of gamma-radiation.

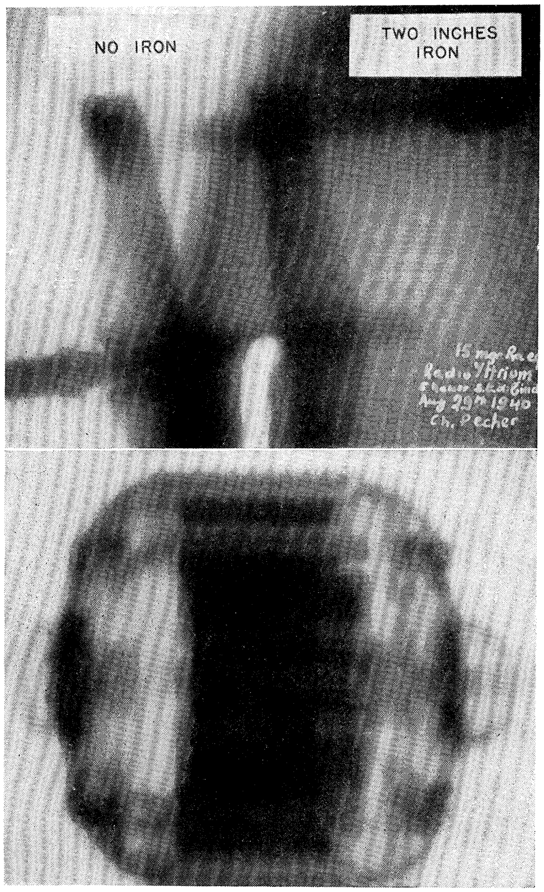

FIG. 1. Gamma-ray radiographs with radioactive yttrium.

CHARLES PECHER*
William H. Crocker Radiation Laboratory,
University of California,
Berkeley, California,
October 14, 1940.

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[1] L. A. DuBridge and J. Marshall, Phys. Rev. **58**, 7 (1940).

* Fellow of the Belgian-American Education Foundation.

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## The Ratio of *e*, *c*, and *h*

The problem of expressing $e$ in terms of $c$ and $h$ splits up in two separate questions. First, if the electronic particle is characterized by its rest energy $mc^2$ and by a basic time $a/c$ ($a=$"radius") then how large is the product $mc\cdot a\cdot \hbar^{-1}=\mu$? The answer of quantum theory[1] is that $\mu$ is the smallest root of the equation $2\pi\mu[y_0(\mu)]^2=1$, namely $\mu=0.02985037$. Second, how large is $a$, or if we write $a=\gamma e^2/mc^2$, how large is $\gamma$? With $\mu$ and $\gamma$ known, Sommerfeld's constant $\alpha$ would be $\alpha=e^2/c\hbar=\mu/\gamma$. The value of $\gamma$ can be obtained from the consideration that $mc^2$ and $a/c$ shall be measurable by one and the same fundamental process characterizing the particle. Since $mc^2$ is the creation energy, $a/c$ must be related to the time duration of a creation process, which in its turn depends on the magnitude of the scattering cross section of the particle for light. Therefore we tentatively identify $a^2\pi$ with the universal scattering cross section $\phi=8\pi e^4/3m^2c^4$ of Thomson which yields $\gamma=(8/3)^{\frac{1}{2}}$. This value is too small, however. The creation cross section must be larger. Now, if we identify $a^2\pi$ with $2\pi\phi$ rather than $\phi$, that is, if we put $\gamma=(2\pi 8/3)^{\frac{1}{2}}$ then we obtain for $\alpha^{-1}$ the value $137.1273\cdots$ in perfect agreement with the best experimental evidence.[2] This result cannot be accidental since the value of $\mu$ was obtained *a priori*, and physical considerations tell us that $a^2\pi$ must be closely related to Thomson's $\phi$. Only the factor $2\pi$ is introduced *a posteriori*. We therefore think that our $\alpha$-formula is the correct one, but the physical origin of the factor $2\pi$ is not yet clear. A simple *classical* theory of the creation is needed similar to Thomson's *classical* theory of the scattering.

ALFRED LANDÉ
Ohio State University,
Columbus, Ohio,
October 16, 1940.

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[1] A. Landé, J. Frank. Inst. **229**, 768 (1940).

[2] F. G. Dunnington, Rev. Mod. Phys. **11**, 65 (1939); R. T. Birge, Phys. Rev. **58**, 658 (1940).

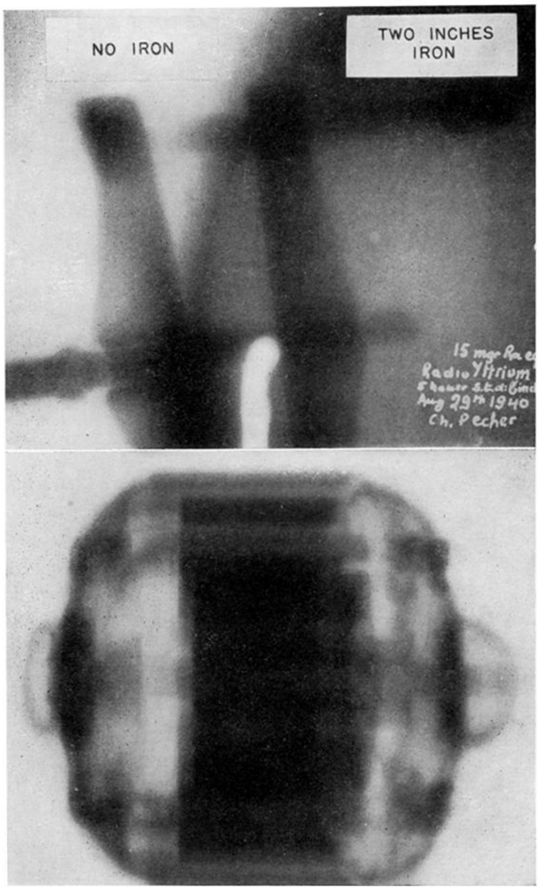

FIG. 1. Gamma-ray radiographs with radioactive yttrium.