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PREPARATION OF A NEW ISOTOPE OF FRANCIUM -- Fr222

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February 4, 1950

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ABSTRACT

A new 14.8 minute beta-emitting isotope of francium has been prepared by high energy proton bombardment of thorium and identified as Fr^{222} by means of its alpha-emitting daughters.

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Predictions from empirical energy systematics in the heavy region indicate that Fr^{222} should have a partial half-life toward β^--decay of about 10 minutes and a partial half-life toward alpha-decay of about 1 day. These predictions were used as a guide in the search for this isotope in the spallation products of Th^{232} bombarded with high-energy protons from the 184-inch cyclotron. The absence of any suitable target isotope with a mass number nearer to 222 necessitated the choice of Th^{232} as the target material which in turn required the use of quite energetic protons to effect the spallation reaction $Th^{232}(p,4z11a)Fr^{222}$. Full-energy protons (348 Mev) produced interference in the form of large amounts of Fr^{212} activity, a description of which appears in a previous communication.[1] 100-Mev protons, however, produced Fr^{222} free of Fr^{212}. The 21 minute beta-emitting Fr^{223}(AcK) and the 4.8 minute alpha-emitting Fr^{221} were produced at the same time and had to be taken into account.

No attempt was made to identify Fr^{222} by its β^--radiation as the method of isolation employed, involving co-precipitation on cesium carrier, introduced an overwhelmingly greater amount of cesium fission product

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[1] E. K. Hyde, A. Ghiorso, and G. T. Seaborg, "Low Mass Isotopes of Francium and Emanation of High Alpha-Stability," UCRL-489; also, Phys. Rev. (March 1, 1950).

beta- and gamma-activity from the proton-induced fission of thorium. Instead, the characteristic alpha-radiations of the Fr^{222} daughters were used in the identification and half-life determination. (See Figure 1.)

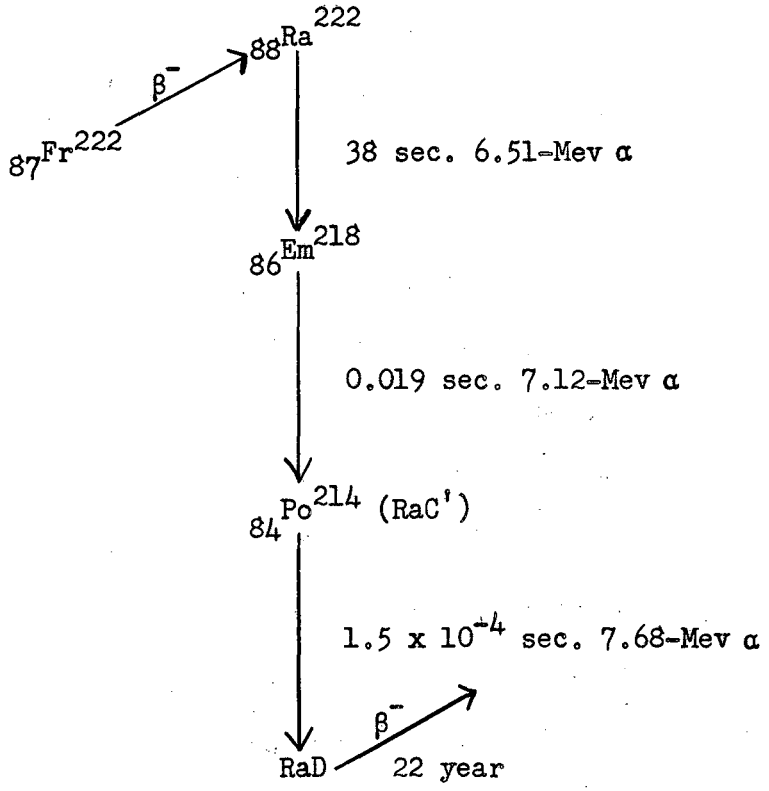

Fig. 1. Decay Products of Fr^{222}

The daughter activities are well known from work on the protactinium series.[2] Interference from the alpha-emitting daughters of Fr^{223} was small because of the relatively long (11.2 day) half-life of the AcX daughter and the alpha-emitting 4.8-minute Fr^{221} had nearly completely decayed before the finish of the francium purification.

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[2] M. H. Studier and E. K. Hyde, Phys. Rev. 74, 591 (1948).

The procedure was to bombard a 5-mil strip of thorium metal foil for 20 minutes with 100-Mev protons. This foil was immediately dissolved in HCl and the francium isolated on cesium carrier by the successive precipitation of cesium silicotungstate and cesium perchlorate, and by volatilization, a procedure described previously.[1] This chemistry eliminated all radioactive contaminants except cesium activity and the francium isotopes Fr^{221} and Fr^{223}.

Aliquots of the purified francium were followed for decay of alpha-activity. (See Figure 2.) After subtraction of the longer-lived activity, coming from α-emitting daughters of AcK, the remainder of the activity showed a straight line 14.8-minute decay. This activity represents Ra^{222}, Em^{218}, and Po^{214} decaying with the half-life of their progenitor, Fr^{222}.

Another aliquot was mounted on platinum and its alpha spectrum determined in the alpha pulse analyzer.[3] Three equal sized alpha peaks were found. These three peaks had the proper energy for Em^{222}, Ra^{218}, and Po^{214} as shown by calibration of the instrument with a sample of U^{230} which was in equilibrium with these isotopes. Pulse analysis was repeated at frequent intervals and the three peaks were observed to decay together with a half-life of 14 ± 2 minutes.

This sufficiently establishes the existence and half-life of Fr^{222}. Very little else can be done at present until a rapid and quantitative

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[3] A. Ghiorso, A. H. Jaffey, H. P. Robinson, and B. Weissbourd, National Nuclear Energy Series, Plutonium Project Record Vol. 14B, "The Transuranium Elements: Research Papers," Paper No. 16.8 (McGraw-Hill Book Co., Inc., New York, 1949).

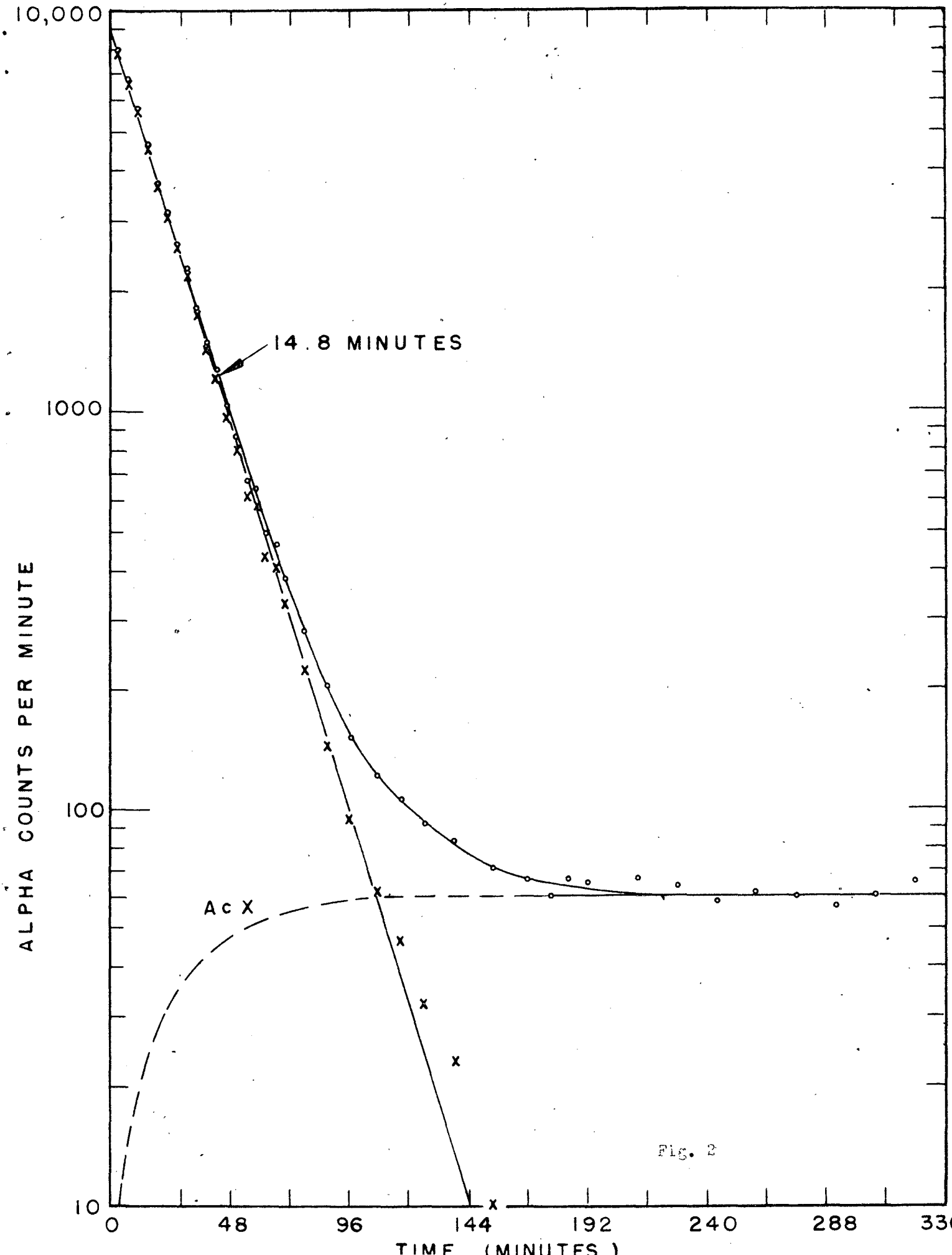
10,000
1000
100
10
14.8 MINUTES
Ac X
ALPHA COUNTS PER MINUTE
0
48
96
144
192
240
288
336
TIME (MINUTES)

Fig. 2

method of separation of francium from other alkali metals, and in particular cesium, is developed.

The assistance of Mr. James Vale and the crew of the 184-inch cyclotron in carrying out the bombardments is appreciated. This research was carried out under the auspices of the U. S. Atomic Energy Commission.