250, 251, and 252) irradiated for six weeks in the MTR, the pile neutron capture cross section of Cf^{252} was calculated to be 25 barns.

Crude calculations of the pile neutron capture cross sections of Cf^{250} and Cf^{251} from mass spectrometric data indicate that these values are about 1500 and 3000 barns, respectively.

A summary of the nuclear properties of the isotopes of berkelium and californium observed in these experiments is given in Table IV.

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Decay of $_{22}Ti^{51}$ (5.8 min)

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The radiations from Ti^{51} have been studied with a scintillation coincidence spectrometer. Gamma rays of 0.32, 0.61, and 0.92 Mev are resolved. Their intensities are estimated to be in the ratio 100:1:5, respectively. The 0.32- and 0.61-Mev gamma rays are in coincidence. Two beta-ray components are resolved; one of approximately 2.3 Mev is in coincidence with the 0.32-Mev gamma ray, and one of 1.8 Mev is in coincidence with the 0.92-Mev radiation. No indication of a beta transition to the ground state of V^{51} is observed.

A SHORT-LIVED radioactivity induced in titanium by irradiation with deuterons and neutrons was first observed by Walke.[1] His tentative assignment to Ti^{51} has been confirmed.[2] A 72-day activity at first believed to be isomeric has been shown[3,4] to be due to contamination of the source. From a careful measurement,[5] the half-life of the short activity is now known to be 5.79±0.03 min. Gamma radiation of 0.32 Mev has been detected by several experimenters.[6–8] Bunker and Starner[8] have reported additional weak gamma rays of 0.60 and 0.915 Mev. They find that the 0.60-Mev radiation is in coincidence with the 0.32-Mev gamma ray and assume the 0.915-Mev gamma ray to be the cross-over transition. A marked disagreement exists between different measurements of the beta transition energies and hence of the total disintegration energy. Der Mateosian[9] found the beta spectrum to be complex, consisting of two components with energies of 1.85 and 2.1 Mev. He observed coincidences between the 1.85-Mev beta ray and the 0.32-Mev gamma ray. Other investigators[2,10] have also reported the maximum beta energy to be about 1.7 Mev. A disintegration energy of 1.7 Mev is much smaller than that expected from a consideration of the energy systematics of odd-mass beta emitters. Koester *et al.*[7] also find the beta spectrum to be complex but report the maximum beta energy to be 2.2 Mev. They conclude that this transition leads to the ground state.

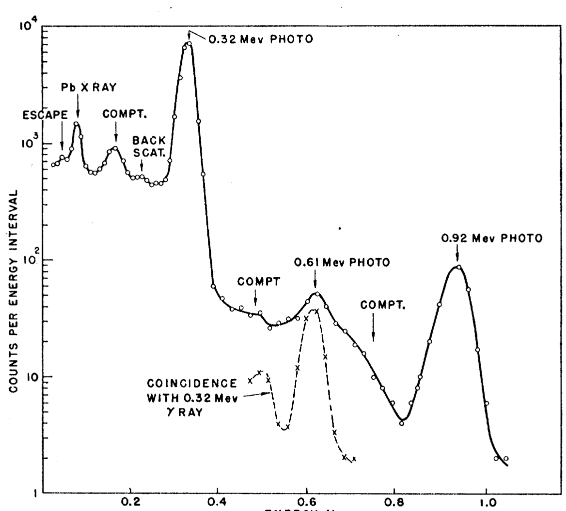

FIG. 1. NaI(Tl) pulse-height distribution of Ti^{51} (5.8 min).

We have undertaken an investigation of the decay of Ti^{51} using our ten-channel scintillation coincidence spectrometer. NaI (Tl) crystals ($2\frac{1}{4}$ in.$\times 2\frac{1}{4}$ in.$\times 2\frac{1}{8}$ in.) were used for the detection of gamma radiation, and an anthracene crystal was used for the detection of beta radiations. The anthracene is provided with a thin aluminum window (<0.001 in.). Sources were

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[8] M. Bunker and J. Starner (private communication).
[9] E. der Mateosian (private communication).
[10] E. Segrè [unpublished data quoted by E. Segrè and A. Helmholtz, Revs. Modern Phys. **21**, 271 (1949)].

prepared by irradiation of TiO_2 (enriched in Ti^{50}) in the Argonne reactor (CP-3′).

The pulse-height distribution associated with Ti^{51} (5.8 min) is displayed in Fig. 1. The data for this curve were obtained with the source approximately one foot from the crystal and with a collimator ($\frac{3}{4}$-in. diameter hole through a 2-in. lead block) interposed. This increases the percentage of full-height pulses and virtually eliminates the possibility of "sum peaks" (simultaneous detection of coincident radiation). Analysis of the distribution confirms the presence of three gamma rays in the spectrum, the intense 0.32-Mev gamma ray and two weak radiations of 0.610 ± 0.015 and 0.920 ± 0.015 Mev. Taking into account the variation in detecting efficiency, the ratio of the intensities is estimated to be 100:1:5. Other peaks and structure in the pulse-height distribution are attributed to secondary processes.

The dashed curve in Fig. 1 shows the pulse-height distribution obtained in coincidence with the 0.32-Mev gamma ray. It is clear that the 0.32- and 0.61-Mev transitions are in cascade. A search for 0.32−0.92 Mev coincidences yielded no counts above the random coincidence rate. The existence of an excited state at 0.92 Mev in V^{51} is thus confirmed. This state decays either directly to the ground state or to the 0.32-Mev level.

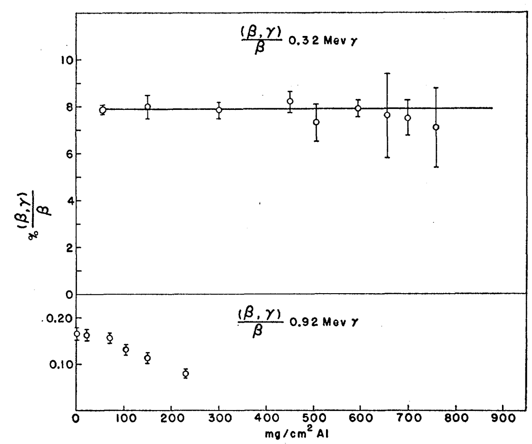

FIG. 2. Beta-gamma coincidences per beta of Ti^{51} (5.8 min).

To determine the total disintegration energy, we measured the energy of the beta rays feeding the two excited states of V^{51}. The ten-channel analyzer was set to accept pulses from the 0.32-Mev photopeak and aluminum absorption carried out on the beta rays in coincidence with this distribution. From analysis of these data a half-value thickness of 135 ± 10 mg/cm² corresponding to a beta transition energy of about 2.3 Mev was obtained. An absorption plot of the counting rate of the beta detector exhibits the same half-value thickness. The similarity implies that little if any beta branching to the ground state occurs. This conclusion is substantiated by the plot of beta-gamma (0.32 Mev) coincidences per beta *vs* absorber thickness, which is seen to be flat as far as the data are meaningful (760 mg/cm²) (Fig. 2). From these data we estimate that the intensity of a ground state beta branch is less than 15 percent.

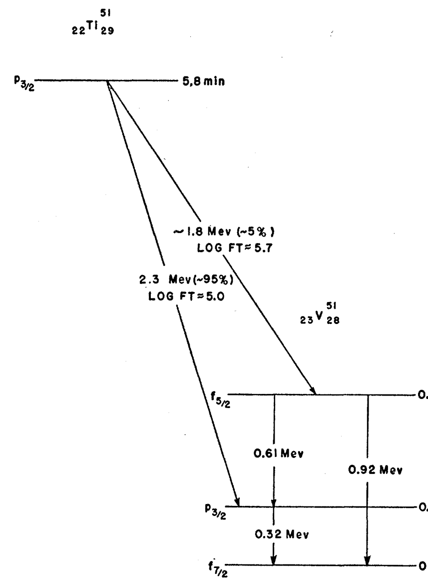

FIG. 3. Decay scheme proposed for Ti^{51} (5.8 min).

In the same manner as above, the beta component feeding the 0.92-Mev state is found to have a half-value thickness of about 95 mg/cm² corresponding to a beta transition energy of about 1.8 Mev. As would be expected, the plot of beta-gamma (0.92 Mev) coincidences per beta is seen to fall off with increasing absorber thickness (Fig. 2). Thus, as earlier reported, the beta spectrum is seen to be complex. However, both branches are shown to decay to excited states of V^{51}. Hence, the total decay energy is established by two independent measurements as 2.6 ± 0.2 Mev.

The decay scheme which we propose is shown in Fig. 3. The spin of the ground state of V^{51} has been measured to be 7/2.[11,12] The orbital assignments indicated are those which would be expected from the single-particle shell model. The log ft values shown for the beta transitions are obtained assuming a five percent branch to the 0.92-Mev state, and indicate that both transitions are "allowed." This is consistent with the assignment of $p_{\frac{3}{2}}$ and $f_{\frac{5}{2}}$ to the excited states of V^{51} and of $p_{\frac{3}{2}}$ to the ground state of Ti^{51}. If the orbital assignment of $p_{\frac{3}{2}}$ to the ground state of Ti^{51} is correct, then a beta transition to the ground state of V^{51} would be "second forbidden."

We are indebted to Dr. M. G. Mayer, whose interest in Ti^{51} stimulated this investigation.

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