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~~DISCOVERY OF~~ ELEMENT NO. 102

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June 4, 1958

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~~DISCOVERY OF~~ ELEMENT NO. 102 *

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June 4, 1958

By the use of a radically new method[1] we have succeeded in identifying unambiguously an isotope of element 102. In other careful experiments[2] conducted over a period of many months we find that we are unable to confirm the element 102 discovery work of Fields et al. reported in 1957.[3]

The experiments at Berkeley were performed with the new heavy ion linear accelerator (HILAC) over a period of several weeks and culminated in the chemical identification of an isotope of fermium (Fm^{250}) as the daughter of an alpha-particle-emitting isotope of element 102 (102^{254}). The method used to detect the isotope of element 102 was essentially a continuous milking experiment wherein the atoms of the daughter element 100 were separated from the parent element 102 by taking advantage of the recoil due to the element 102 alpha particle decay.

The target consisted of a mixture of isotopes of curium (95% Cm^{244} and 4.5% Cm^{246}) mounted on a very thin nickel foil. The target was approximately 0.5 mg/cm^2 thick and was covered with 75 $\mu gm/cm^2$ aluminum to prevent curium "knockover". The curium was bombarded with mono-energetic C^{12} ions at energies from 60 to 100 Mev. The transmuted atoms were knocked into helium gas to absorb the considerable recoil energy. It was found that with a sufficient electric field strength practically all of these positively charged atoms could be attracted to a moving negatively charged metallic belt placed directly beneath the target. These atoms would then be carried on this conveyer belt under a foil which was charged negatively relative to the belt. Approximately half of the atoms undergoing alpha decay would cause their daughter atoms to recoil from the surface of the belt to the catcher foil (see Fig. 1). The catcher foil was cut transversely to the direction of the belt motion into five equal length sections after a time of bombardment suited to the half-life of the daughter atom to be examined. The five foils were then alpha-pulse-analyzed simultaneously in a multiplex assembly consisting of five Frisch grid chambers, amplifiers, a single Wilkinson type "kick-sorter", and a printer. With this equipment it was easily

possible to make all the desired measurements for identifying the atoms caught on the catcher foils and thus to measure the half-life of the parent of the recoiling atoms. The method was first successfully used in bombardments of Pu^{240} with C^{12} ions to identify a new isotope of element 100, Fm^{248}. It was shown to have a half-life of 0.6 minutes by analysis of the amounts of the 20-minute Cf^{244} caught on the catcher foils.

Experiments were then started which were aimed at finding a short-lived isotope of element 102. The most likely isotope of element 102 that could be detected with this method was deemed to be 102^{254} with a predicted half-life of seconds leading to the 30-minute, 7.43-Mev, alpha-particle-emitter, Fm^{250}. The first experiments showed that the electrostatic shielding between the target and the catcher foil was not complete enough, since some of the originally produced atoms such as Cf^{246} were found on the leading edge of the catcher foil; additional shielding reduced this problem to insignificance. In a series of experiments it was found that Fm^{250} could be collected on the catcher foils in accordance with a parent of half-life 3 seconds produced in the reaction $Cm^{246}(C^{12},4n)\ 102^{254}$ (see Fig. 2). The excitation function for producing Fm^{250} in this manner was found to peak sharply at 70 ± 5 Mev corresponding to a $(C^{12},4n)$ reaction in accordance with a recently developed method for calculation of (C,xn) reaction cross-sections.[4] That the atoms collected are ejected by alpha recoil of atoms from the belt is proved by the fact that neither Cf^{246} nor Cf^{245} which are collected in far greater amounts on the belt are found prominently on the catchers. Changing the belt speed was found to change the distribution of the Fm^{250} on the catcher foil in a manner conforming to a three second parent. The number of Fm^{250} counts observed in a single experiment was as great as 40 and corresponded to a maximum cross-section of a few microbarns for the reaction with Cm^{246}. Nuclear-emulsions placed above the moving belt to receive the alpha particles from the decaying 102 atoms are being scanned to determine the alpha energy of the 3-second 102^{254} but there are difficulties with this method since there are hundreds of times as many tracks due to Fm^{250}, Cf^{245}, Cf^{246}, and other alpha emitters.

The final identification of the activity ascribed to Fm^{250} was carried out by dissolving the activity from the catcher foil and separating it from the other actinide elements by elution with ammonium α-hydroxyisobutyrate from a column packed with Dowex-50 cation exchange resin.[5] In one experiment 2 atoms of Fm^{250} were identified and in another 9 atoms were observed in the element 100 position (see Fig. 3); there can thus be no doubt that we have identified element 102 in these experiments. We are deferring the naming of element 102 to a later date.

We would also like to report some very recent experiments designed to look for alpha activity from as yet undiscovered element 103. The same curium target was bombarded with ca 0.3 microampere of (+7) N^{14} ions. The atoms of 103, such as 103^{256} from the $Cm^{246}(N^{14},4n)$ reaction, would presumably be collected on the conveyer belt as in the other experiments. The belt speed was 3 inches per second since the half-life of an isotope such as 103^{256} would be expected to be a fraction of a second. Nuclear emulsions placed just above the belt to receive the long range alpha particles from the decay of this nuclide have been examined carefully for such corresponding tracks. We have found 16 tracks with an energy of 9 ± 1 Mev and positions in the nuclear emulsion consistent with a half-life of approximately 1/4 second. These tracks could be due to an isotope of element 103 but from these crude preliminary experiments it is of course not possible to rule out the possibility that they are due to the production of new nuclides between polonium and thorium from tiny lead or bismuth impurities or are due to prompt alpha particles produced by the interaction of neutrons with the belt material. Work is continuing in an effort to trace the source of this activity.

We are indebted to E. Hubbard and the many physicists and engineers of both Berkeley and Yale whose excellent design work have made the successful operation of the HILAC possible. The cooperation and hard work of the crew of the HILAC is gratefully acknowledged.

The engineering of the various pieces of target equipment was performed very ingeniously by C. Corum and we owe much of the success of our new methods to his excellent painstaking work. To A. E. Larsh and D. F. Mosier we extend our thanks for working out the details of the new multiplex pulse analyzer system which was the heart of our detecting system.

We would like to thank R. Garrett, C. Rossi, and J. Mahoney for their cheerful and tireless assistance in carrying out many of the operations which have provided the necessary background for the experiments which have been described. The early phases of this work were carried out with the helpful collaboration of G. R. Choppin, S. G. Thompson, T. Parsons, G. Gordon, L. Phillips, and R. Gatti.

We would like to express our appreciation to Professor C. M. VanAtta and Professor E. O. Lawrence for their continuing interest and encouragement in this research.

REFERENCES

1. A. Ghiorso, a more detailed account of some of these new experimental techniques is being prepared for publication.

2. See Letter "Attempts to Confirm the Existence of the 10-Minute Isotope of 102".

3. P. Fields, et al., Phys. Rev. 107, 1460-1462 (1957).

4. Sikkeland, Thompson, Ghiorso, (Phys. Rev., in press).

5. Choppin, Harvey, and Thompson, J. Inorg. and Nuclear Chem. 2, 66 (1956).

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†On leave from Joint Establishment for Nuclear Energy Research, Kjiller, Norway.

FIGURE CAPTIONS

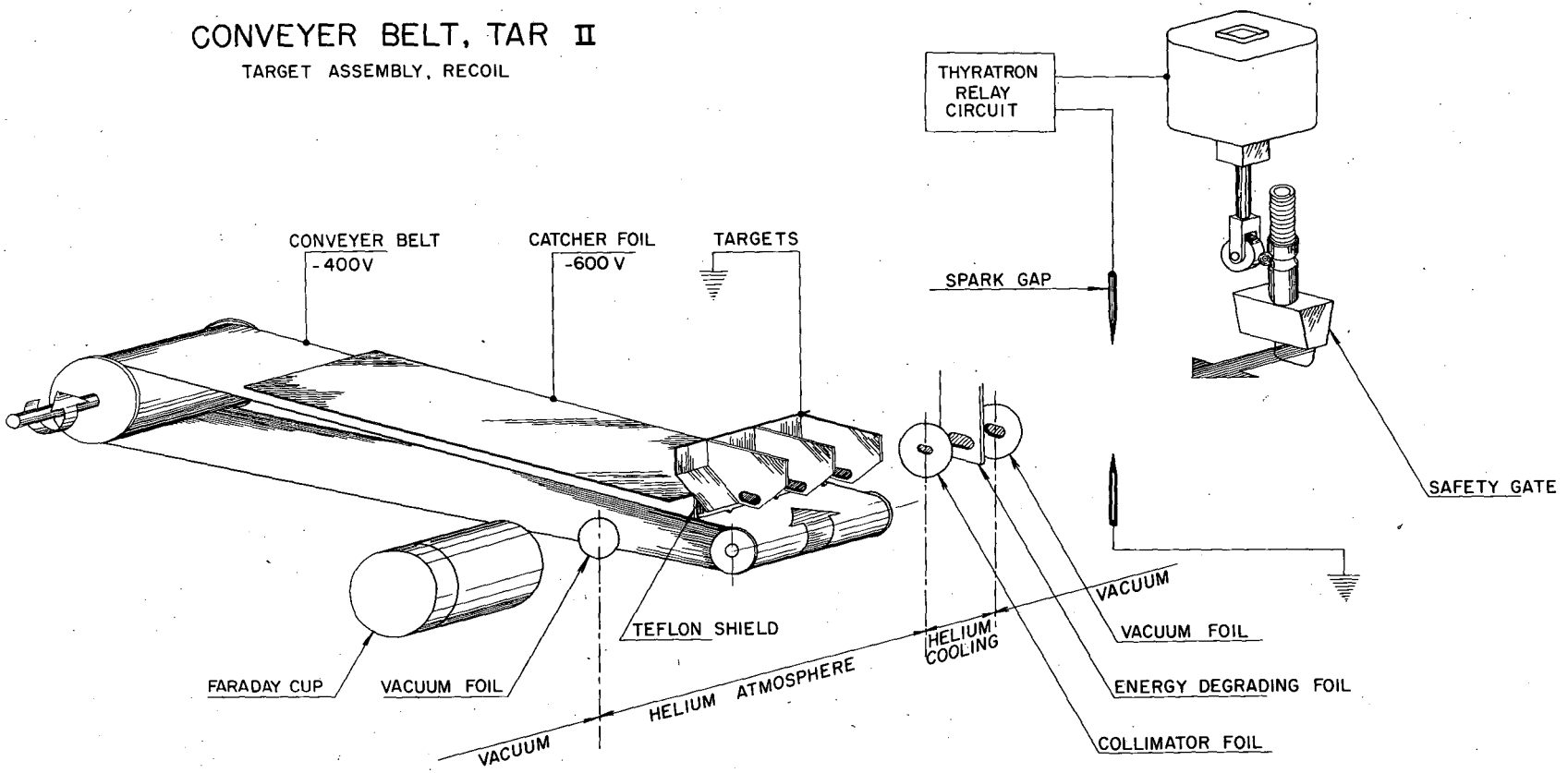
Fig. 1. Schematic diagram of conveyer belt experiment.

Fig. 2. Determination of half-life of 102^{254}. Data from combined results of many experiments.

Fig. 3. Ion exchange elution curve of the Fm^{250} daughter of 102^{254}. The Tm, Y, E^{253}, and Cf^{252} activities (scale on left) were incorporated as tracers for calibration purposes.

CONVEYER BELT, TAR II

TARGET ASSEMBLY, RECOIL



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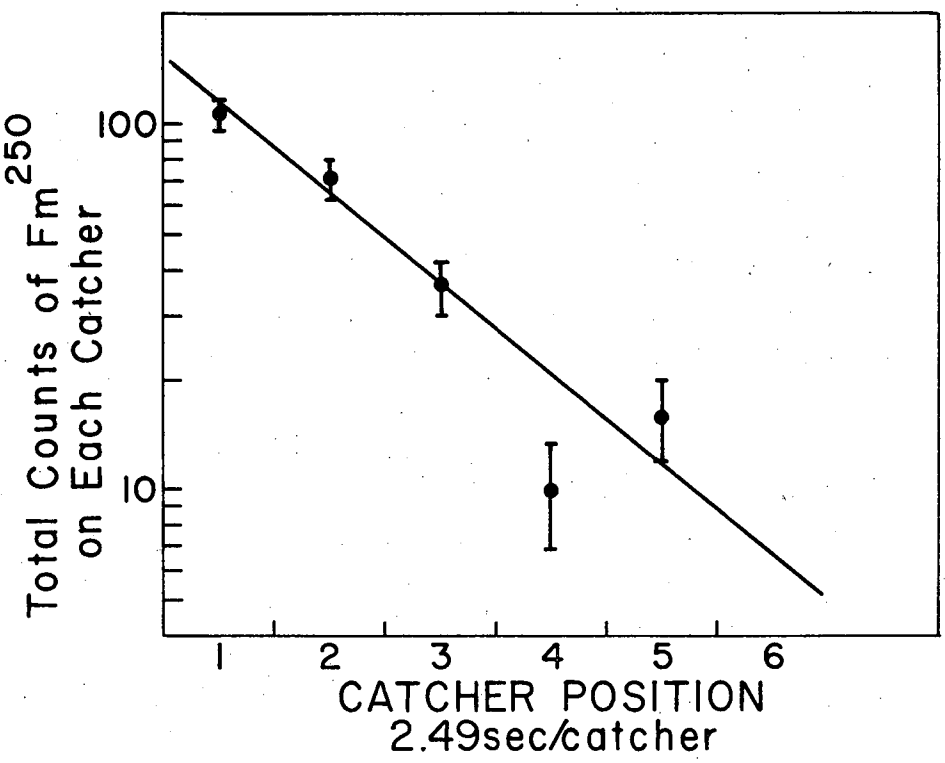
Total Counts of Fm^{250} on Each Catcher
100
10
1
2
3
4
5
6
CATCHER POSITION
2.49sec/catcher
MU-15,316

Fig. 2.

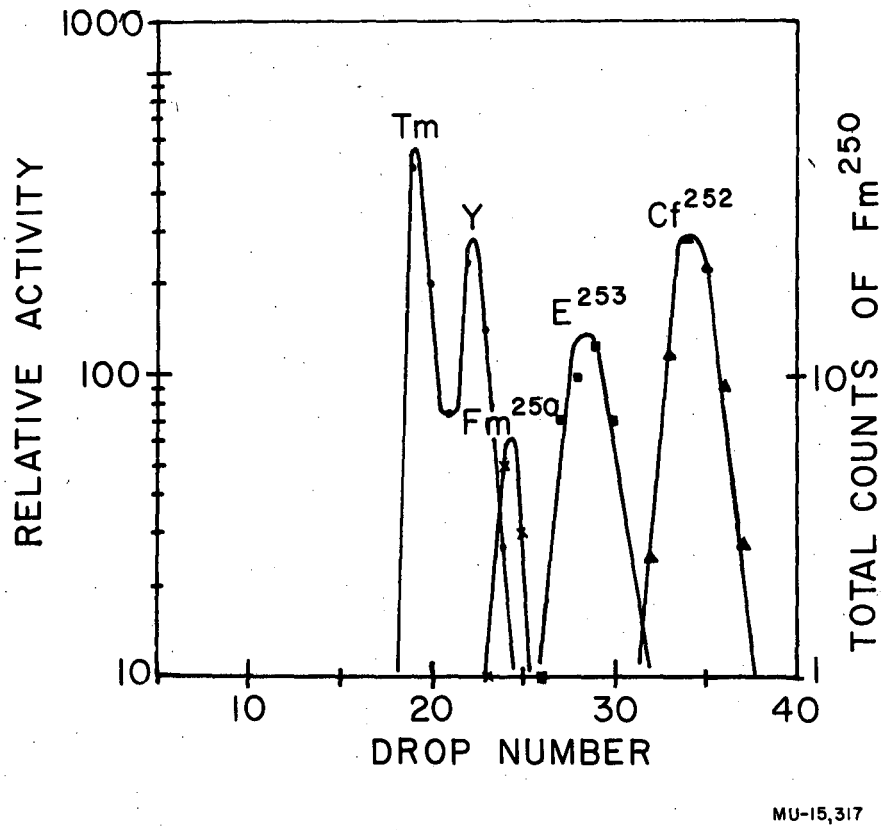
1000
100
10
RELATIVE ACTIVITY
Tm
Y
Fm250
E253
Cf252
10
1
TOTAL COUNTS OF Fm250
10
20
30
40
DROP NUMBER
MU-15,317

Fig. 3.