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Bombardments of californium with boron ions have produced alpha particle activity which can only be ascribed to decay of a new element with atomic number 103. This activity at best amounts to only a few alpha counts per hour ($\sigma \approx 1$ microbarn) so it has not yet been possible to detect the mendelevium decay product to prove further the atomic number of the new activity. For the present, attribution of this activity to element number 103 must rest entirely on nuclear rather than chemical evidence.

The method used to produce and identify radiations from element 103 decay is shown schematically in Fig. 1 and is based on the one used for the element 102 experiment.(1) The 3 microgram californium target has an isotopic composition at present of 3.3 % 249, 32.8 % 250, 12.3 % 251, and 50.8 % 252.(2) It was electroplated in November 1960 in an area 0.10 inches in diameter onto nickel foil 50 microinches thick. The purification of the target, crucially important for the success of the experiment, consisted in careful use of ion exchange columns with specially purified reagents. The last step in the purging of undesirable lead and bismuth impurities was accomplished by heating the final target in vacuo by electron bombardment. Lead and bismuth impurities must be reduced because heavy ion bombardment of these elements produces in high yield an alpha activity with an 8.8 Mev alpha particle energy and a 25 second half life which can obscure the lower energy alpha activity of element 103. The heavy ion beam of either B^{10} or B^{11} was collimated so as to pass through the tiny target

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(1) A. Ghiorso, T. Sikkeland, J. R. Walton, and G. T. Seaborg, Phys. Rev. Letters 1, 18 (1958).

(2) We are indebted to M.C. Michel for the mass analysis.

and typically was limited to 0.5 microamperes d.c. to avoid melting the target foil. The transmuted atoms recoiled from the target into an atmosphere of helium. This gas flowed slowly through a nearby .050 inch orifice and carried the electrically charged transmutation products to a thin copper conveyor tape. This tape was periodically pulled a short distance to place the groups of collected atoms to positions successively in front of each of five solid state Au-Si surface barrier detectors. The pulses caused by passage of alpha particles into each detector were amplified, except for a few milliseconds during the beam bursts, by separate preamplifiers in the shielded bombardment area and then sent to a main counting area to be further amplified and analyzed. In the counting area, the pulses were passed through separate window amplifiers and then analyzed by two separate electronic systems. One system consisted of five separate 100-channel pulse analyzers and the other consisted of a multiplex unit using five punched paper tape storage units. With the multiplex unit, it was possible to determine the time when each event occurred since the conveyor tape was last advanced.

The silicon crystal detectors vitally necessary for the experiment were brought to the authors' attention by C. J. Borkowski and J. L. Blankenship of the Oak Ridge National Laboratory. With their very kind help, it has been possible in our laboratory to make silicon detectors suitable for these experiments. The present detectors are made of 800-1800 ohm-cm silicon, 6x10 mm, suitably etched and mounted, and are covered with a layer of gold about 20 micrograms per cm^2 thick. Initially, it was found that operation of these detectors was very erratic because of the helium atmosphere and the very intense beta radiation fields. The use of charge sensitive preamplifiers reduced this effect but it is still found that because of the circumstances of the experiment, it is necessary to replace the crystal detectors occasionally.

The energy of the boron ions was changed by degradation of the 10.3 Mev per nucleon beam in aluminum absorbers. Because the beam is so intensely concentrated, it was found that the amount of energy loss in a given absorber could change with time. To monitor the energy of the ions striking the target, another Si detector was calibrated against nuclear emulsions, and used at a small solid angle to measure the energy of those ions scattered forward at 20° by the faraday cup window.

Calibration and study of the total system without beam was accomplished with either U^{230} recoil products collected onto the tape or with Po^{212} alpha particles from samples held in front of the detector assembly. Studies of the method with heavy ion reactions were made by bombarding Sm^{147} to produce short-lived holmium alpha emitters or Pb and Bi to produce various alpha emitters with energy between 7 and 9 Mev.

In the bombardment of Cf with B ions, the activity attributed to element 103 consists of alpha particles with an energy of 8.6 Mev decaying with a half-life of 8 ± 2 seconds. Also observed are alpha particles of 8.4 and 8.2 Mev with similar half-lives of about 15 seconds which are probably due to element 102. Fig. 2 shows an alpha particle spectrum from the first detector obtained during the most recent set of runs. These activities have been observed repeatedly during many weeks of bombardment of the californium target with both B^{10} and B^{11} ions. Similar bombardments of Pb, Bi, Pu^{240} and Am^{241} do not produce the new activities.

The mass number of the element 103 isotope is thought to be 257 for the following reasons. B^{11} bombardments of Cf^{250}, Cf^{251}, and Cf^{252} cause compound nucleus reactions which lead to 103^{257} by the emission of 4, 5, or 6 neutrons while with B^{10} this same result is accomplished with 3, 4, or 5 neutrons. These are known from other experiments to be the most prominent neutron-out reactions

of boron with the transuranium elements. Excitation functions with B^{11} and B^{10} ions for production of the 8.6 Mev alpha activity are consistent with the above deduction.

These excitation functions were, of necessity, very broad because the same activity could be produced by several reactions; consequently this data could not rule out conclusively (B,pxn) reactions which would produce light isotopes of element 102. The final proof was then accomplished by accentuating the element 102 production by bombarding the californium target with C^{12} ions. It was found that the 8.6 Mev activity was decreased by more than a factor of 2 and the 8.2 Mev activity (thought to be mostly 102^{255}) was increased by a factor of about 20. This was to be expected for the element assignments given. Experiments with Pu^{240} had shown that the (C^{12}, α xn) cross-sections would be larger while the (C^{12},pxn) cross-sections would be smaller in comparison with the boron bombardments of californium. Possible light isotopes of mendelevium that could be produced and conceivably might emit alpha particles in the 8.2 - 8.6 Mev region were ruled out by bombardments of Am^{243} with C^{12} ions.

In honor of the late Ernest O. Lawrence, we respectfully suggest that the new element be named lawrencium with the symbol Lw.

The element 103 experiment has been in the process of development for almost three years and its successful culmination has been due in no small part to the help of all of our colleagues. We would like to particularly express our appreciation to the following: to F. Grobelch for his tireless assistance in innumerable ways both with the accelerator and the experimental equipment; to J. Gavin, the HILAC operators, its engineering and maintenance personnel for their patient production of the many hundreds of hours of boron beam operation; to C. Corum for his always ingenious mechanical designs which were the backbone of the experiment; to S. G. Thompson, L. Phillips, R. Gatti, F. McCarthy, and T. Parsons for their separation of the californium from the "napkin-ring" material; to R. Garrett for her continuous capable assistance; to A. Wydler for his very able multiplex design and construction; to W. Goldsworthy for his competent

amplifier designs; to W. Stockton for his indispensable silicon detectors; and to B. Isaacs and S. Hargis for their very good-natured help in the data processing. Special acknowledgment is due to the Health Chemistry Department under P. Howe for its skillful handling of a very difficult radioactivity protection problem. We are also indebted to F. Asaro, I. Perlman, and G. T. Seaborg for helpful discussions regarding interpretation of these experiments.

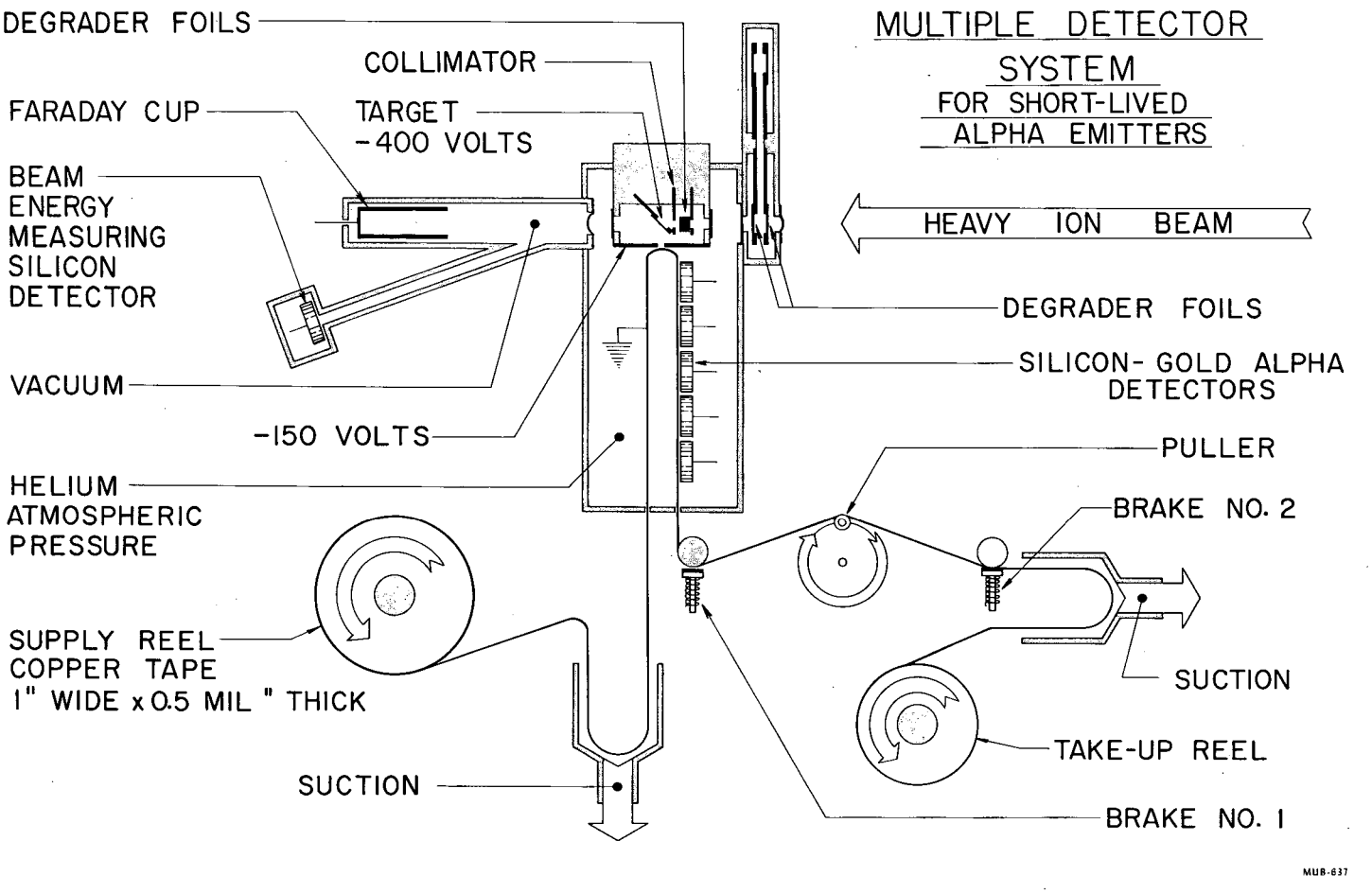

Fig. 1. Schematic diagram of apparatus.

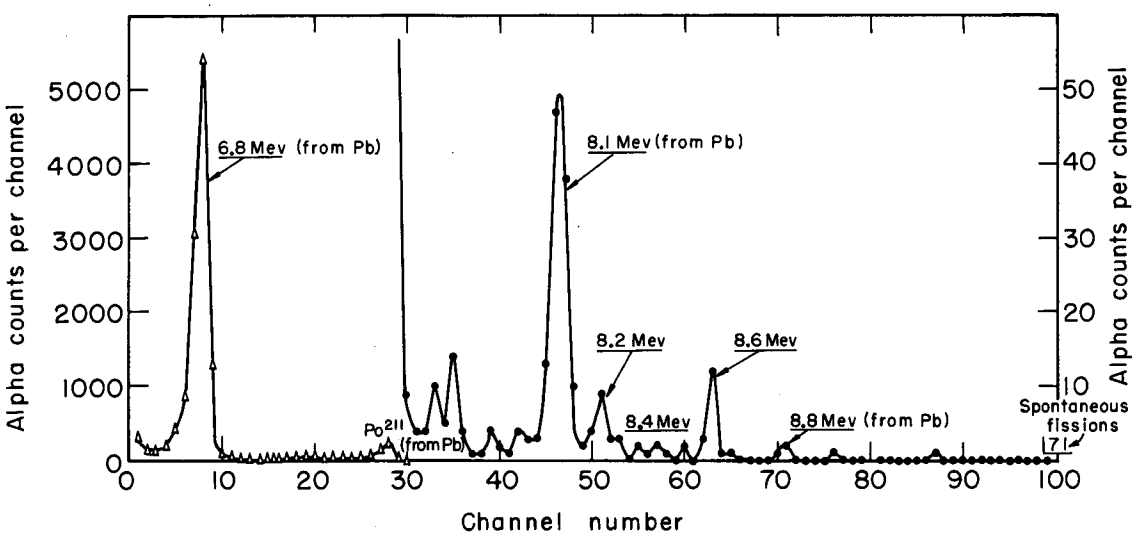

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Fig. 2. Cf + B^{11}. Alpha spectrum from first detector. Summation of Runs Nos. 139-148. Total bombardment = 5.0 μahrs. Cyde time = 15 seconds. 23 March 1961.