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Authors
Walker, Robert J.
Corbin, Tommy R.
Haley, James T.

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University of California

Ernest O. Lawrence Radiation Laboratory

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Summary

Simple solid-state counter systems were designed and used as "column counters" during separation of the transplutonium elements. The work was done in a Berkeley Enclosure in the 6-ft water-cave facility at the Lawrence Radiation Laboratory, Berkeley, California

Problem

In the column separation of Cf, Cm, Es, and Fm one must somehow be able to tell when the drops coming off the column contain the elements of interest. The means employed previously was to transport each fraction to a suitable counter at some location that was remote from the extreme background conditions that exist in the enclosure. This involved excessive handling of very highly active material. Even though the handling of active material is one of our particular skills, we maintain that the less handling one does, the better. The amount of time required to transport the fractions back and forth was also of concern. These circumstances prompted the development of detectors that could function in the presence of approximately 10^9 n/sec and 10^5 R/hr of fission products. Other design considerations were small size, corrosion resistance, and the ability to be decontaminated without removal from the enclosure. Of course, all considerations were tempered with thoughts of moderate cost.

Solution

Surface-barrier solid-state (ss) detectors fulfilled the requirements for both types of counters. As an alpha counter the ss detector has excellent discrimination against gamma and beta radiation, and is practically insensitive to fast neutrons. As a neutron counter the ss detector, now equipped with a polyethylene converter foil, is also insensitive to alpha but becomes moderately sensitive to fast neutrons. What makes it useful as a column neutron counter is that its neutron sensitivity is unidirectional, because fast-neutron moderation is preferentially forward and the neutron proceeds away from the source.* As

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* D. J. Hughes, Pile Neutron Research (Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1953), p. 28.

shown in Fig. 1 the neutrons coming from the loaded column strike the backside of the converter foil and the resulting recoil proton proceeds out the front face and away from the ss detector. Thus, the intense background, caused by the neutrons coming from the column, does not affect the detector. However, the recoil protons formed by neutrons striking the front face of the foil proceed into the detector and are counted. A drop containing 0.1 μg of Cf^{252} (approximately 10^5 n/sec) can easily be detected in the presence of a column loaded with 100 μg of Cf^{252} (approximately 10^8 n/sec). Many times this amount could be accommodated before the scattered background becomes noticeable.

Equipment

The ss detectors are silicon surface-barrier types with approximately 0.5 by 1 cm active area. The alpha detector is protected by a removable Mylar window (approximately 1 mg/cm^2) which can be changed if it becomes contaminated. It has a nominal point-source efficiency of 15%. The neutron detector has a 1/16-in.-thick polyethylene converter foil mounted in close proximity to the detector face. This foil is also removable in case of contamination. Both detectors are connected via minax cable to preamplifiers mounted on the outside of the enclosure. The preamplifiers drive cables that bring the signal through the water shield to the count-rate-display panels at the operator's location. Figure 2 shows the simple circuitry required.

Results

Figure 3 shows a column with the detectors in place. The upper one is the alpha detector; it counts the drops as they form. Figure 4 is a plot of the Cf^{252} alpha counting rate vs drop number. The data were taken during a cleanup column operation. They are labeled 1 through 30; however, about 200 previous drops were collected, but they showed no alpha count and could be discarded without further investigation.

Figure 5 is a plot of the count rate resulting from a butt column run showing a maximum for each successive element. No neutrons are counted until the Cf starts coming off the column.

The lower detector is the fast-neutron detector. It is tilted forward to insure that any background neutrons from the column must enter the backside of the converter foil, thus avoiding detection.

Both count-rate circuits have audio outputs which further aid the operators in confirming the separation. When a drop forms, the alpha audio output builds up until the drop falls, at which time the audio indication abruptly stops. If the drop under consideration contains Cf^{252}, upon reaching the bottom of the collecting cone it will cause a response in the neutron detector. As more drops are collected, the neutrons counting rate increases up to some maximum. When the neutron counting rate does not increase any further, and the alpha count has reached a minimum, the Cf^{252} has been separated (see Fig. 4).

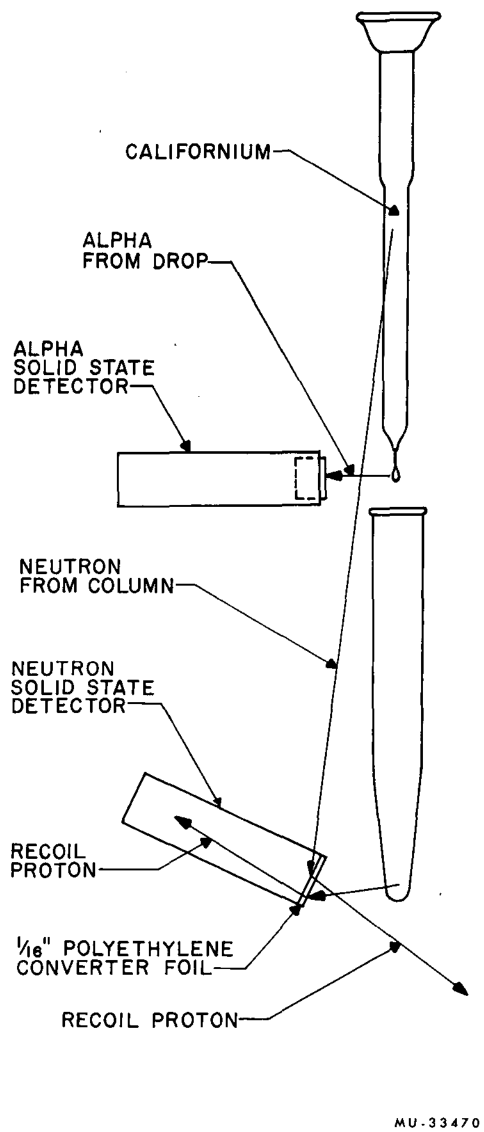

Fig. 1. Illustration of unidirectional response.

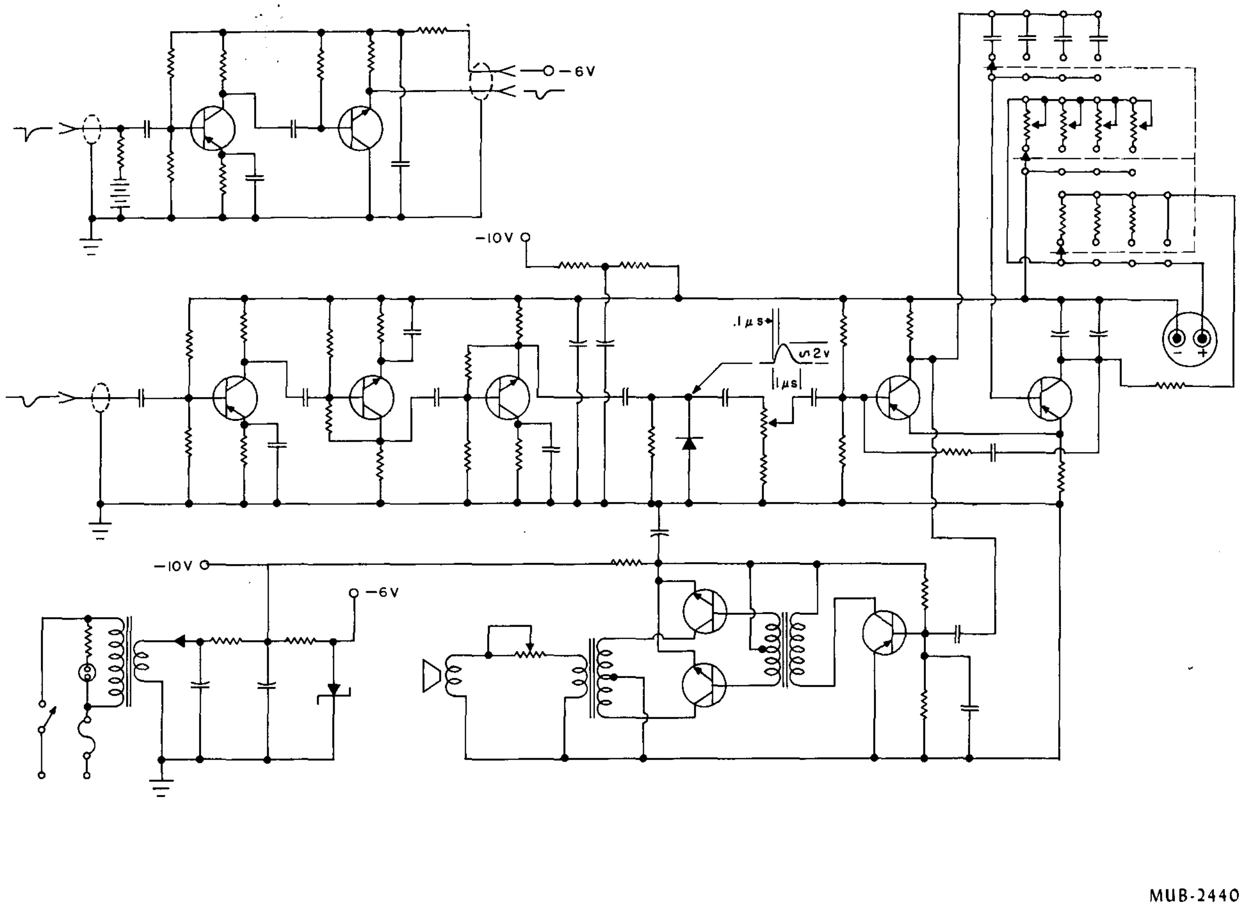

Fig. 2. Circuit schematic

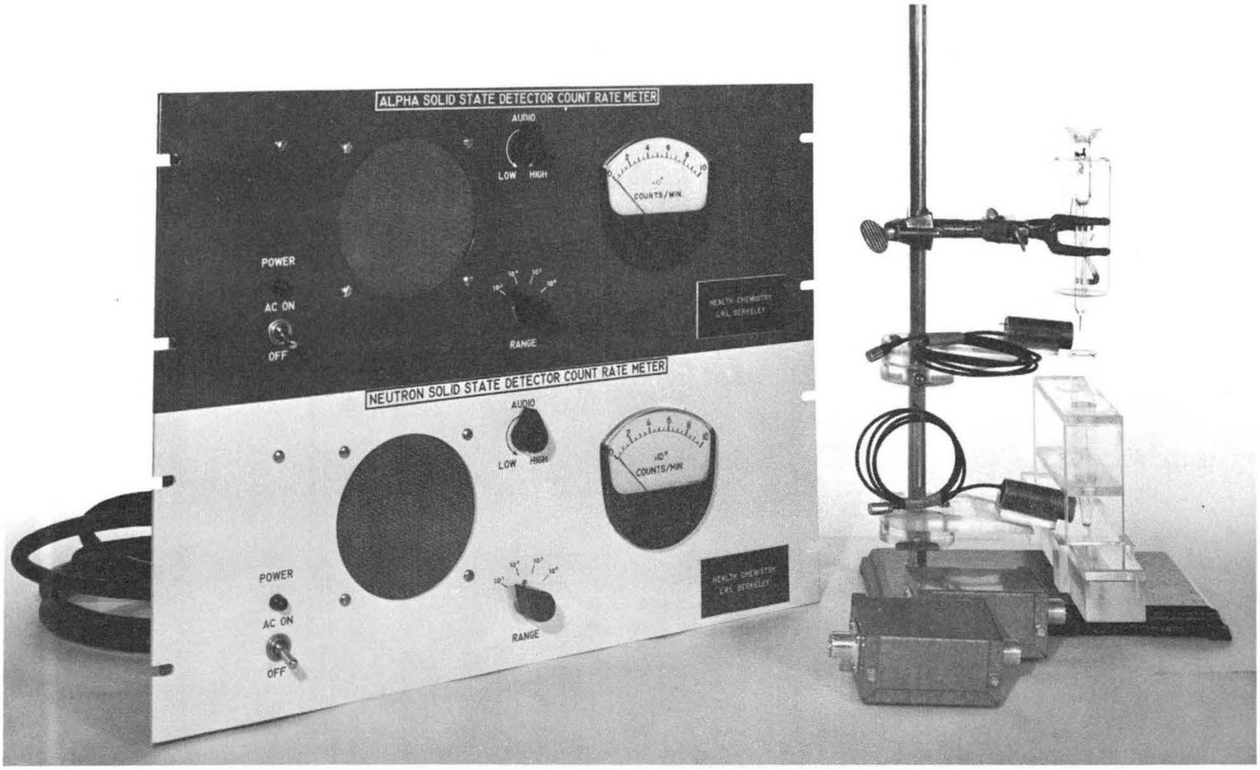

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Fig. 3. Complete system showing detectors in place.

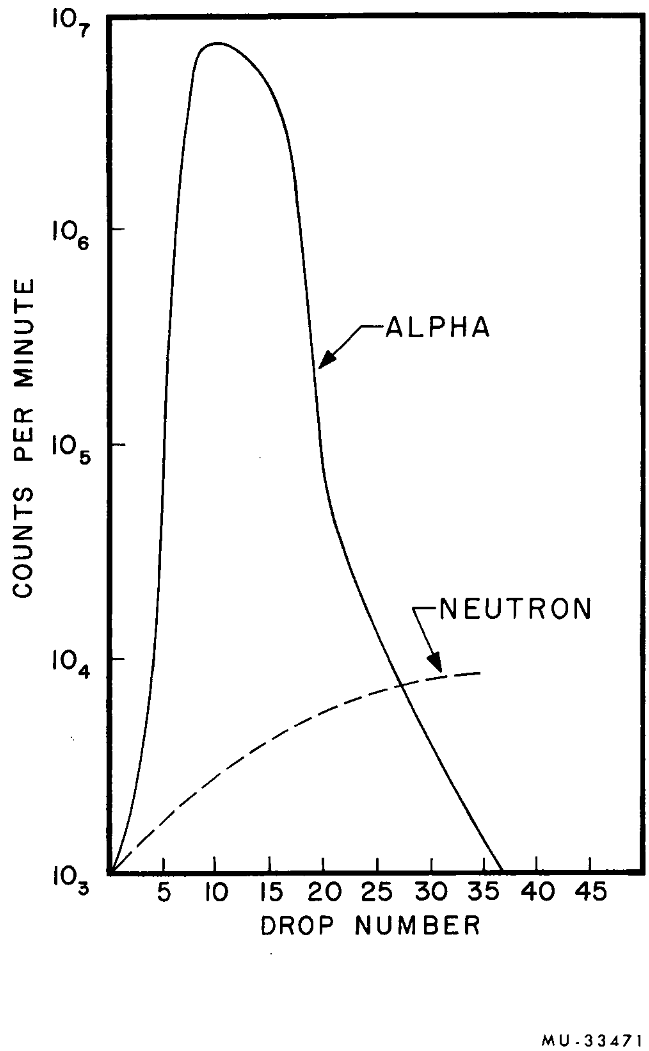

Fig. 4. Count rate plot of a Cf^{252} cleanup column.

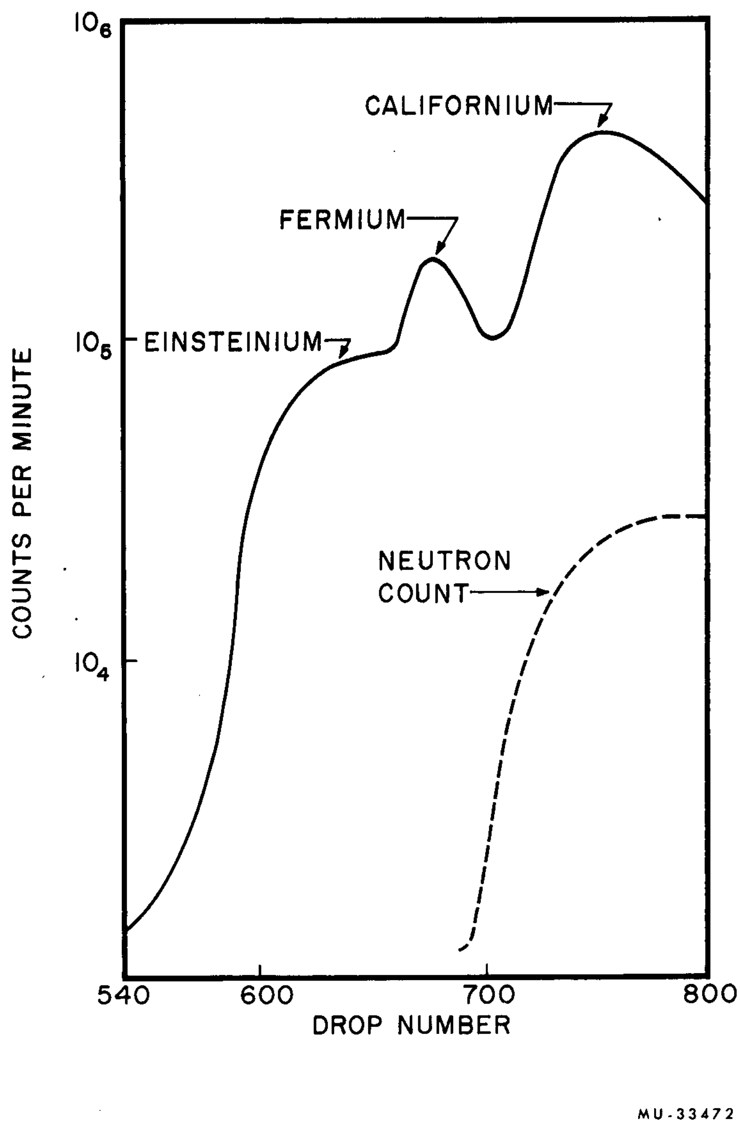

Fig. 5. Count rate plot of a butt column.

No attempt has been made to obtain quantitative information because of the many variables involved. In the future, however, by standardizing techniques, it may be possible to obtain yield data as well as separation data.

This work was done under the auspices of the U. S. Atomic Energy Commission.