

2. MEASUREMENT OF CONTAMINATED INDIVIDUALS

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The human counter with its superior geometric design offers the possibility of detecting incorporated gamma emitting isotopes at a level much lower than the maximum permissible concentration (MPC). Therefore, a number of German companies working with radioactive isotopes have taken advantage of the situation and periodically send their employees to be measured in the human counter. In several cases, incorporations much below the maximum permissible concentration were found.

Also, in the normal measurements of cesium-137 and potassium, about which Dr. Onstead has just spoken, a few individuals have been seen with high counts which could not be explained by their cesium-137 and potassium-40 content. Usually, these people had never worked with radioactive isotopes and had never even realized that they had had an incorporation. In those cases, the personal history was thoroughly checked and it was usually found that the individual has had an illness 20 or more years ago at which time thorotrast might have been administered. A special measurement was then made to be certain that it was thorotrast.

In order to make measurements which show what isotope was present in the contaminated individual and in what quantity, the counter was calibrated with the different

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isotopes in question. As very often there was an incorporation of more than one isotope, a way to separate the counts of the different isotopes had to be found. As the resolution in such a large liquid scintillation counter is very poor, one might think that this is impossible.

Figure 1 shows the gamma spectrum of different isotopes as measured in the counter. These spectra show a resolution of about 40% for the potassium-40 peak and of about 50% for the cesium-137 peak. As for cobalt-60, the two peaks at 1.1 and 1.3 MeV were not separated; but a big help in identifying cobalt-60 is the small peak at a higher energy which results from the summation of the two energies. Both radium-226 and thorium-228 have a large number of gamma lines in the spectrum and no differentiating peaks, but an overall energy distribution is characteristic, especially for thorium-228 with its high energy end. For these reasons, a particular energy measurement was never tried, but instead, measurements in several channels were made. From the ratio of the counting rates in the different channels, it was attempted to calculate which isotopes were present. Usually, measurements were made in three channels. One channel was fixed for the energy peak of cesium-137, the second for potassium-40, and the third covered an energy range from 1.8 to 3 MeV. With the first two channels fixed at the peak energies of cesium-137 and potassium-40, a correction for the normal potassium-40 and cesium-137 content of the human body could be obtained. With three channels there was the possibility of separating three different isotopes, providing the ratio of the counting rates was known. In most instances, not more than three isotopes would be incorporated. Up to now, there were no cases in which the isotopes present could not be identified. There would be a possibility that, by using a multichannel analyzer, four or five gamma emitting isotopes could be separated.

Now, I will present two examples of these measurements. The first was an isotope handler who was working with cesium-137, cobalt-60, radium and thorium. From his counting results in the first two channels, it was clear that he had an incorporation of cesium-137 and cobalt-60. The ratio of the counting rates in the second and third channels was the same as was found by an earlier calibration with just cobalt-60 in these channels. This shows that the individual had no appreciable amount of radium-226 and thorium-228 incorporated. These results were checked with several urine samples. The urine samples were ashed and then measured

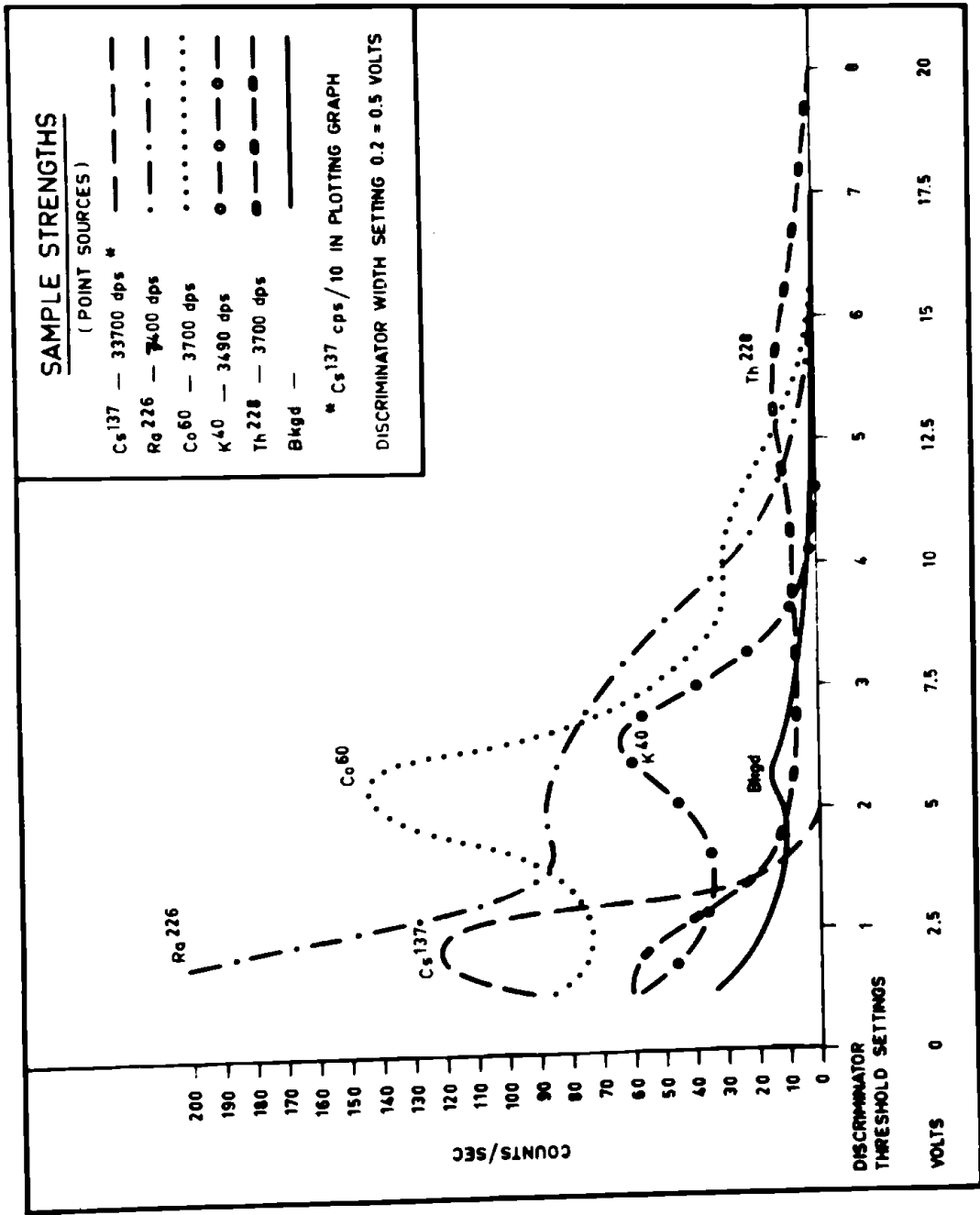


Fig. 1. Gamma spectra from the Landstuhl Human Radioactivity Detector.

for alpha and gamma activity. However, only normal alpha activity was found in the urine. This would not have been the case if radium or thorium had been incorporated.

From measurements of exhaled radon, a second isotope handler was seen to have radium-226 incorporated. When this individual was measured in the human counter, the ratio of the counting rates for three channels was not as expected from the previous calibrations with radium-226. The counting rate in the first channel was much too high as compared with the second and third channel. Therefore, an incorporation of a second isotope with an energy similar to that of cesium-137 was suspected. A measurement of an ashed urine sample in a well type scintillation crystal showed clearly the cesium-137 peak. With a second measurement five months later, a biological half life of 144 days was calculated which was a second indication that it was cesium-137.

When calibrating the human counter for the measurement of radium-226 and thorium-228, it was taken into account that these isotopes are mostly deposited in the bones. Therefore, a polyethylene phantom, Fig. 2, (called Silent Sam) was used which has hollow spaces in the spinal column, arms, and legs. Into these hollow spaces glass tubes containing the isotope under consideration were inserted. Around the spaces (formed from polyethylene tubes) that contain the glass rods, distilled water was introduced to act as the body flesh.

Silent Sam has a second advantage in being hollow. When calibrating with thorostrast, the solutions could be placed at different parts of the body. The organs in which it is deposited, depending on the medical application, could be liver, spleen, kidney or neck tissue.

It was expected that from measuring these patients, the metabolism of the daughter products of thorium could be ascertained. Accordingly, a separation between the gamma rays of mesothorium and the daughter products of thorium-228 has been made, as shown in Fig. 3. Line No. 1 gives the gamma spectrum of a thorostrast solution, line No. 2 shows the gamma spectrum of thorium-228, and line No. 3 gives the difference of the two which is then the gamma spectrum of mesothorium. Taking the counting ratios of our three channels when measuring an individual who has incorporated thorostrast, the equilibrium between mesothorium and thorium-228 can be examined.

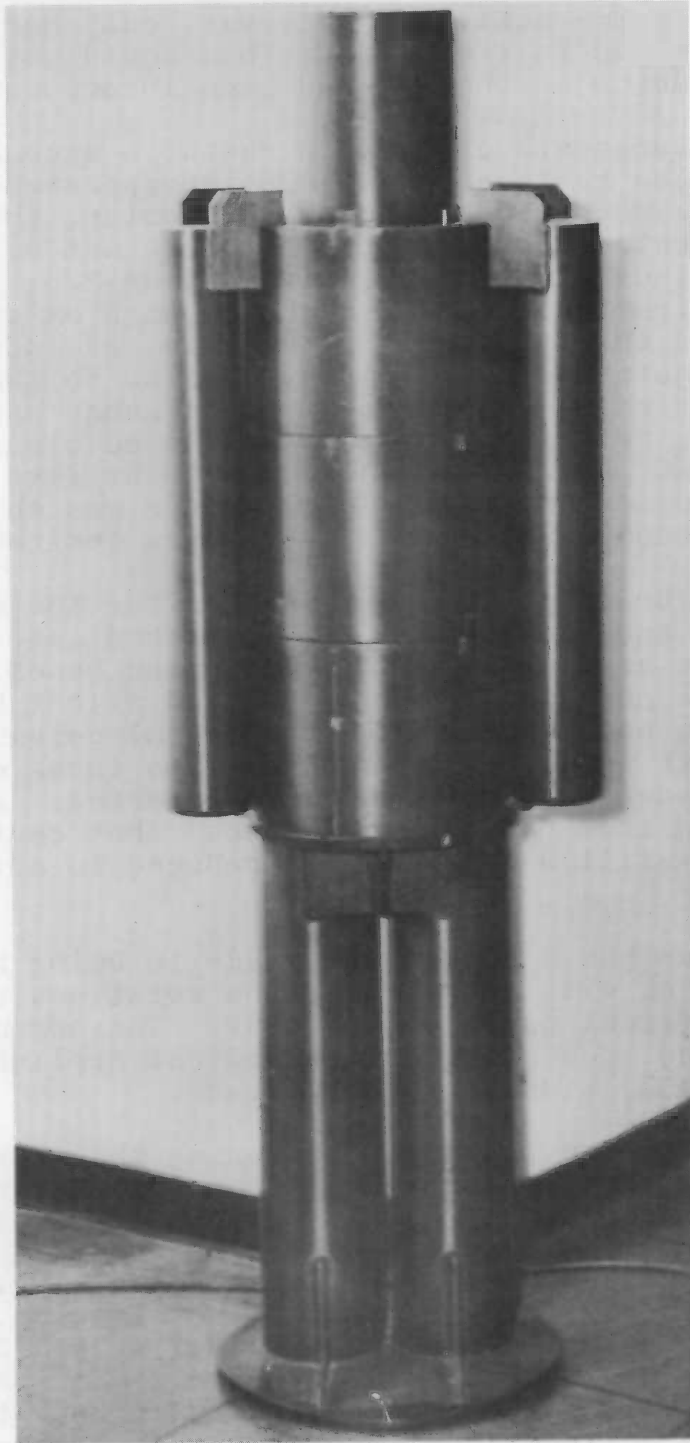


Fig. 2. "Silent Sam" the polyethylene phantom.

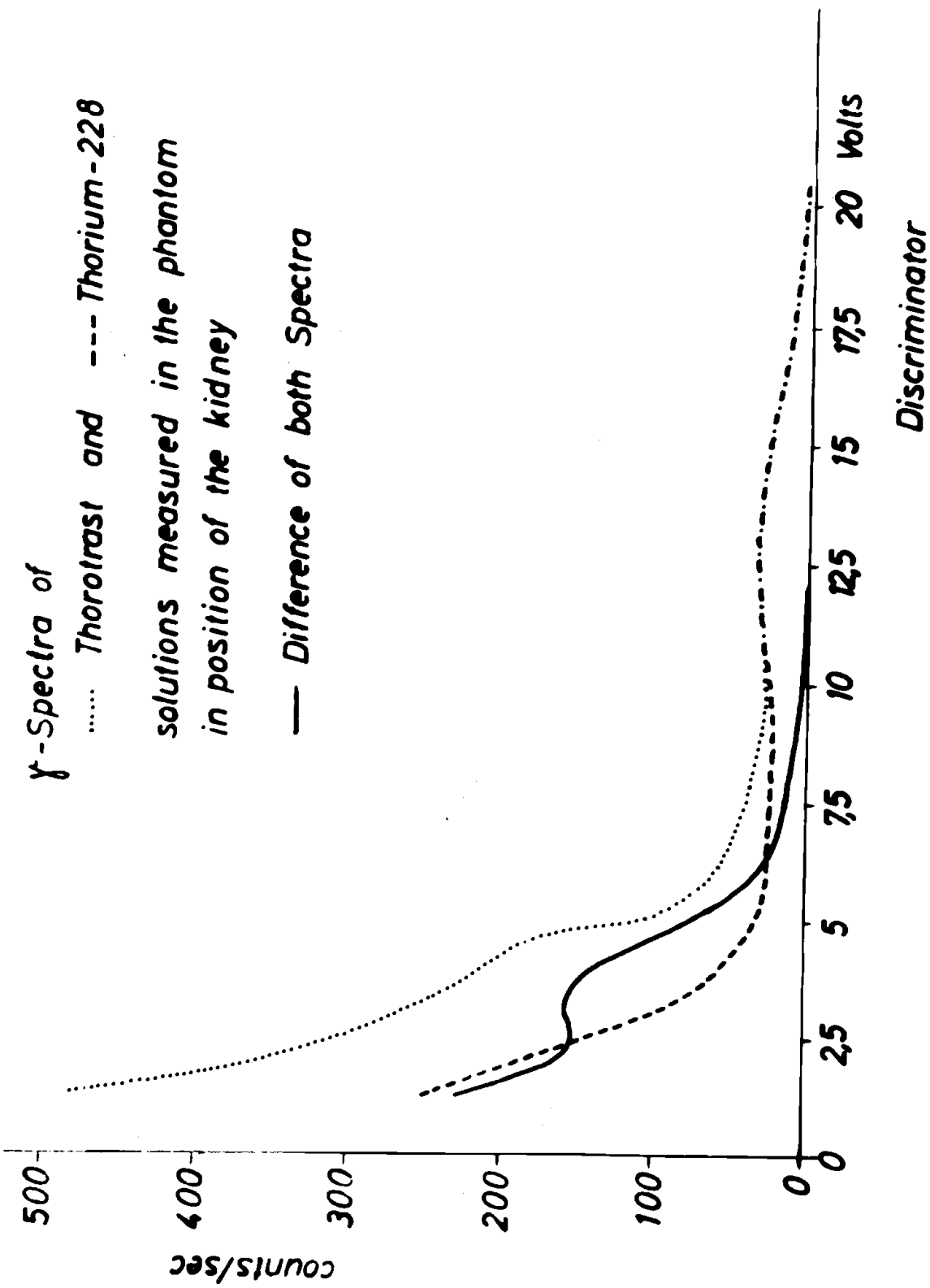


Fig. 3. Thorium spectra from the Landstuhl Human Radioactivity Detector

When comparing the Landstuhl results with those of Rundo (1), it is seen that the "wash-out" for the whole body is not as big as was found for separated organs. The explanation might be that part of the daughter products is washed out of the original deposits and then relocated at other parts of the body. All these measurements on thorotrast patients are part of a more extensive program which is now being conducted at the Landstuhl Human Radioactivity Detector and the Institute of Biophysics of the University of the Saar, Homburg.

REFERENCES

- (1) J. Rundo, *Physics in Medicine and Biology* 1:138-146 (1956).