in which we demonstrated space-charge neutralization was basically the Dempster-type mass spectrograph. The so-called "Calutron" used in the Oak Ridge electromagnetic separations plant was also basically a Dempster-type mass spectrograph. It lends itself to electron neutralization of the ion beam space charge because the geometric separation of the ions of different isotopes takes place in a region free from applied electric fields.

A little-known aspect of the Manhattan Project was another effort to carry out quantity separation of uranium-235 by electromagnetic means. This work was performed early in the war at Princeton University with a concept referred to as the "Isotron." It was based on velocity modulation of an ion beam with time-variant electrical fields applied between drift spaces. This method did not lend itself to effective space-charge neutralization by electrons, a limitation also observed in the earlier work at Cornell and discussed in (*1*). The Isotron project was discontinued in 1943, and the wartime electromagnetic separations work was concentrated on the Dempster-type mass spectrographic approach being developed at the University of California Radiation Laboratory at Berkeley.

Those of us who were involved in that frenzied effort frequently speculated on what the counterparts of our apparatus looked like in Japan and Germany. As it turned out, there were none. Even if the scientists of those countries had solved the space-charge problem of the electromagnetic method, it is unlikely plants could have been constructed and operated to carry out the necessary quantity of uranium-235 separation. The bombing attacks during the later phase of the war would have been too disruptive.

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References

1. L. P. Smith, W. E. Parkins, A. T. Forrester, "On the separation of isotopes in quantity by electromagnetic means," *Phys. Rev.* 72, 989 (1947).

While my own research corroborates nearly all of what Deborah Shapley reports on Japan's attempts to build an atomic bomb (News and Comment, 13 Jan., p.152), the fact is that Japan lacked adequate long-range aircraft like the B-29 and by 1943 had inadequate capabilities to even launch a second attack on Hawaii. A much more likely scenario would have been for Japan to resort to using its bomb in China, Okinawa, or even the Soviet Union.

Some Japanese newspapers have chosen to give the *Science* article front-page coverage, perhaps because it comes at a time when Japan has a near-capability of building weapons using fuel reprocessed at its pilot reprocessing plant.

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Science, Media, and Worst-Case Limits

How can one discourage misuse of worst-case limits in the public domain? One approach is to widely publicize the fact that such misuse is unprofessional, unethical, and results in slanted information. When worst-case limits are misused, the transgressors should be taken to task.

The news media often report the results of criminal trials. In those cases where a defendant is found guilty on multiple counts, before sentencing it is standard procedure to describe the limit of possible sentences by assuming that each count will result in the maximum punishment and that prison time for each count will be served sequentially. Thus, a 60-year-old man found guilty on six counts, each with a 20-year maximum penalty, is described as being subject to a possible sentence of 120 years, notwithstanding the impossibility of such a sentence being carried out. It should be noted that the 120-year sentence even has a legal connotation, namely, that parole would not be possible for 60 years (in many jurisdictions) should the maximum sentence be implemented.

Regardless of the impossibility and meaninglessness of such a sentence, there has been no apparent public confusion or concern about the use of such numbers by the media. This lack of concern may be explained by the fact that there are criteria understood by the public that allow them to evaluate the statement with proper perspective. The limited life-span of individuals and the rarity of such sentences ever being completed are self-evident, and this may prevent misinterpretations.

I call this tendency of the media, the public, scientists, and others to make an estimate of the worst-case limit in the case above and in other situations the "penal syndrome." Just as an average is a central measure of a range of possible measures, the upper (or lower) limit of the range of possible measures is also a valid, but often inferior, way of describing quantifiable conditions. However, the use of such upper limits in many situations is made without the criteria necessary to put these limits in reasonable perspective. It is typical for the media and the public to focus on these upper limits, and to do so without qualifications.

As an example, consider the case of plutonium toxicity. Although there is no case on record of a fatality caused by plutonium in humans (*1*), it is often said that plutonium is one of the substances most toxic to humans and that 200 million body burdens can be held in a single teaspoon. Certainly body burdens are a useful comparative measure of the relative toxicity of substances that can be absorbed by an "average" human; but without reference to the relative ability of such doses to reach the human body, they have no meaning in any absolute way. The critical pathway to the human body for plutonium is inhalation of insoluble particles of plutonium oxide (within a limited size range). Conversely, the toxin that causes botulism, the body burden limit for which is often compared to that for plutonium, is highly soluble in water and can reach the human body more easily (*2*).

In science, extreme limits are useful measures. They may be used on either an absolute or relative basis; in the latter case systems may be compared against each other at their limits. However, for both there is now an understandable reticence by many scientists to state worst-case limits for fear of misuse by the media and others. This impedes the transfer of important information.

One cannot fault the media for wanting to use worst-case limits, as they make news more marketable. The fault lies in using them without qualification in cases where important criteria for discrimination are absent, where propagation of such limits takes place out of context, and where purposeful misuse occurs.

In any case, the professional community must preserve its right to use and publish all information for public understanding without the menace of possible misuse. A concerted effort to identify and criticize misuse as cited is an important duty that accompanies the right to free exchange of information.

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Notes

1. There may or may not be statistical fatalities among the total population resulting from plutonium exposure, but cause-effect relations cannot be established except when test animals have been given very large doses.
2. Further confusion may arise from the delayed effects of ^{239}Pu exposure being measured in years while those of the botulism toxin are measured in hours. Thus the comparison of body burdens alone is inferior to other measures as a way of describing relative toxicity.