at Breslau, Heidelberg and Berlin, one of the founders of spectrum analysis, discoverer of cesium and rubidium, originator of Kirchhoff's laws of electricity and contributor to the theory of partial differential equations. The name is frequently mispronounced to sound like "Kerchof" in English, which at least has the virtue of being related to the spelling.

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Dean refers to somebody named "Kirkhoff." Is this by any chance the physicist Kirchhoff?

You may appreciate the following verses that have been circulating in the mathematics community:

Weep for the mathematicians
Posterity acclaims:
Although we know their theorems
We cannot spell their names.

Forget the things you thought you knew—
Henri Lebesgue has got no Q

The Schwarz of inequality
and lemma too, he has no T

The "distribution" Schwartz, you see
Is French, and so he has a T

Hermann Grassmann—please try to
Spell his names with 2 N's, too

Although it almost rhymes with Birkhoff
Two H's grace the name of Kirchhoff

Fejér, Turán, Cesàro, Fréchet—
Let's make the accents go that way,

And as for (Radon-) Nikodým,
Let's give his accent back to him.

But there is one I leave to you,
Whatever you may choose to do:
Put letters in or leave them out,
Dress them with accents round about,
Finish the name with -eff or -off,
There *is* no way to spell Чёбышев

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More on fission vs. coal

The exchange between G. Eggermont and Joseph Devaney in April (page 13) on coal vs. fission was an interesting one. However, one major fact has apparently been overlooked. According to G. Eggermont "A 1000-MWe nuclear reactor releases practically no radioactivity . . ." and Joseph Devaney agrees " . . . even confining ourselves just to regular radioactive emissions, the coal-fired plant turns out to be much worse than a fission reactor . . ." The assumption of negligible gaseous radioactivity releases from nuclear power plants, especially BWR's, is not a good one.

The average annual noble-gas release for nine operating BWR's in 1974 was in excess of 613 000 curies per reactor, with an average of 203 effective full power days of operation per reactor.[1]

The gaseous I-131 release rate for nuclear reactors Dresden II and III was measured over a 2 ½ month period in 1973, and was found to lie in the range 0.01 μCi/sec to 0.1 μCi/sec.[2] Assuming 220 full-power days of operation, the total annual release of I-131 would lie in the range of 0.19 curies to 1.9 curies. The estimated annual airborne release of I-131 is given in the above reference to be 0.467 curies per year per reactor.

In addition, Joseph Devaney states that ". . . from fission plants the limitations (on emission of radioactivity) are extreme . . ." Actually there is no upper limit to the amount of radioactivity that can be released by a nuclear power plant provided that the utility can demonstrate that the requirements of 10 CFR 50, Appendix I are met for off-site doses.

References

1. NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR-GALE-CODE)," April 1976, pages 2–13.
2. T. R. Marrero, J. M. Smith, C. D. Wilkinson, "Airborne Iodine-131 Released from Boiling Water Reactor Plant," *Power Engineering*, Feb. 1977, pages 45, 46.

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THE AUTHOR COMMENTS: Robert Scully's letter is a sample-in-microcosm of what I am driving at. For, even to a reader of considerable knowledge, Scully's "613 000 curies" emitted per reactor-year appears to be a frightening number. (This number, by the way, is for older boiling water types—newer BWR's emit less, and pressurized water reactors emit substantially less. The average release of the important Kr-85 is about 500 curies per reactor-year.) It is my central thesis that because such isolated numbers, while of interest, are so misleading, one should compare *hazards*, indeed not just *radioactive* hazards, and not just for *part* of the fuel cycle, but for the whole cycle and for all hazards. Only in this way can the public and the Congress properly judge

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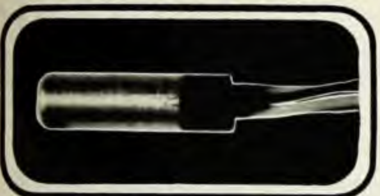

letters

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the merits and deficiencies of coal versus fission power.

Permitted radioactive releases depend and ought to depend on hazard, that is, on potential human dose. Thus to disintegration rate one must add transport to humans, bodily acquisition, biological residence time, energy of radiation, absorption probability, ionization density, and the like, to arrive at a man-equivalent dose (in rem's). It is in the sense that restrictions on dose imply in turn restrictions on radioactive release that there are "from fission plants ... limitations that are severe and—in comparison to other risks we routinely accept or are necessarily exposed to—absurd."[1]

As far as I can discover, it is in fact true that "... even confining ourselves just to regular radioactive emissions, the coal-fired plant turns out to be much worse (i.e. more hazardous) than a fission reactor ..." because the coal-fired plant emits more toxic radioactivities, which are carried to humans more readily, are retained longer and with higher energy, and have higher ionization density radiation than the noble gases (10.7 year Kr-85 and 5.3 day Xe-133) of routine reactor emission. One curie of equal parts of Ra-226 and Ra-228 is approximately radiobiologically equivalent to 400 000 curies of Kr-85 and 400 curies of I-131.[2] In addition (except for short-lived radon) uranium, thorium and their daughters ride along or travel as particulates; krypton and xenon are noble gases, and their higher transport to, and deposition in, the human lung can further multiply the relative biological coal risk, perhaps many fold. Moreover, even the disintegration rates at plant boundary can be 500 to 1 000 000 times higher from a coal-fired plant than from a fission plant, as Jawoworski *et al* have reported elsewhere.[3]

But all this comparison between radioactivities is beside the main point, because the principal hazard of coal is chemical and non-radioactive physical. Radioactive hazard comparisons, which consequently need only be very roughly comparable to coal hazards to make the point, are only mentioned to inform those who feel that cancer, mutations and deaths from radioactivity are somehow more deadly than the same cancer, the same mutations, or the same type of deaths caused by the chemical and non-radioactive physical toxicants of coal. Strict radioactive hazard comparisons are thus for perspective only, and can be omitted from the main thesis. Clearly, to make the proper decision among the available large-scale fuels, one must consider the total hazards from the complete cycles, of course including disposal and the chance of catastrophic accident. Thus far, the best comparative hazard numbers I have found favor use of fission power over coal power by more than sixty to one. Perhaps by very much more than sixty to one, when the details of all toxicants and of particle transport and lung retention are included. Further, the fission wastes are being controlled; not only are the coal wastes not well controlled but, also, much coal waste is emitted in a form guaranteeing nearly maximum human hazard.

My fears expressed in this series of letters to PHYSICS TODAY have early come to pass, for with a sense of utter defeat I note that the new Federal administration is plunging into maximum reliance on coal without regard, indeed without awareness, that coal is so much more hazardous than fission power. They are, in addition, sincerely believing (and reassuring the public) that human health and the environment will not suffer. For what little it is worth, all my private studies indicate that the combined technical, political and economic realities strongly contradict that belief. An additional point about the future is that not only is coal much too hazardous to burn, but it is also too valuable. With the pending early exhaustion of natural gas and oil, coal is now to take up the slack; figuring it then as a replacement for virtually all power sources and as a chemical feed stock, one can come up with numbers as low as only seventy years or so of economically recoverable US coal reserves.

Sadly, I also report that an additional 2000 MWe coal-fired power plant is now to be built near Farmington, New Mexico, and that the Navajo Nation has announced their own 350 MWe coal-fired plant. The Navajos have a chant, an abridged part of which goes: "... In beauty, I walk! With beauty before me, with beauty behind me, with beauty below me, with beauty above me, with beauty all around me, I walk ..."

No more.

References

1. A. R. Muller, "Natural Radiation Background versus Radiation from Nuclear Power Plants," Jour. Environ. Sci. July–Aug 1972, page 9.
2. M. Eisenbud, H. G. Petro, "Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuels," Science **144**, 288 (1964).
3. Z. Jawoworski *et al*, "Environmental Surveillance Around Nuclear Installations," Vol. I, IAEA, Vienna (1974), page 403.

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5/2/77 *Los Alamos, N.M.*

Correction

July, page 67, middle column, five lines up—"Present solar-cell arrays are about twice as heavy ... because 20 micron silicon solar cells are used" should read "200 micron silicon solar cells."