coal-fired power plant (order of 10^{23} submicron particles per day), which alone pollutes vast areas (observed at 100 000 square miles) of a four-state region. The airborne particle-size distribution peaks at 0.8 microns and is composed of spherical shells.

To add to the technical difficulties of control of the highly damaging submicron particles one must take practical note of the political and economic probabilities of getting even the most modest state-of-the-art control. These coal-fired power plants represent on the order of $200 000 000 investments, now much more, (2000 MWe). They hire many people; they financially and politically dominate whole regions and they vigorously protect their profits and freedom from governmental control. They have every economic incentive (and large ones at that) to do so. For instance, I believe the maximum air-pollution fine in New Mexico presently is $1000 per event (not per day, or per pound of pollutant, or per injury). I leave it to the reader's imagination as to how often this fine has been imposed on so rich and powerful an entity in a poor, lightly educated, job-hungry state like ours.

In sum, coal-fired pollution control is so bad and is foreseeably so bad, that one might only be a little wrong to say that pollution control is nearly as bad as no control at all. It *has* been said by many that the laws are but "a license to pollute." So Eggermont's confidence in "classical" controls and in 99.8% by weight removal is unfounded.

However, there are prime areas of our power problem in which we can all agree. Of the economically viable fuels it is clear that we want to utilize the least hazardous and polluting. At the present time and for the near future, the only large-scale alternatives are coal and fission. The hazards of the latter have been highly studied and publicized. We need to do the same for the former, coal. Indeed, many governments are rushing post haste to place severe restrictions on fission power that will necessarily make coal power more attractive to power-plant executives. How if coal be worse? How if coal be very, very, much worse?

Consequently I submit that the question before us is not: "Is fission power safe?" but rather: "What is the comparative hazard of the whole cycles of the two alternative fuels?" Most needed are further studies of coal hazards. Least needed, because we have already many studies in hand and because of the misuse already being made of them by the public and others, are the non-comparative publication of further fission-cycle safety studies I have tried to warn against.[7] Above all, because the public, the state and national governments and the power-plant executives are deciding right *now* on the fuel cycles that will be used during the remainder of the lives of most of us, we need complete comparative studies, however approximate, however premature, so long as they are timely (with apologies to the authors of the magnificent studies already made). To avoid misuse, I further recommend that every specialized study in these fields include a statement, as complete as possible, indicating the net effect of the findings on the *ratio* of total hazards of coal to nuclear fission power for the same produced electric power.

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11/22/76 *Los Alamos, New Mexico*

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5. See, for example, R. L. Rock et al, "Evaluation of Radioactive Aerosols in the United States Underground Coal Mines", US Department of the Interior Report 1025 (1975).
6. L. B. Lave, as quoted by N. Rasmussen, lecture, Los Alamos Scientific Laboratory, c. 1974.
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In praise of engineering

I have followed the discussion on engineering physics in PHYSICS TODAY and the *Forum Newsletter* with some interest, having been a 1962 graduate of the program at the University of Oklahoma. From my perspective of today, I could not be more pleased with the program I followed there or the education I received. I would personally urge all physics departments that have a School of Engineering available to explore seriously the option of an engineering-physics curriculum.

I think of myself as both a physicist and an engineer. I have since received a Master's degree in physics (from the University of Washington, a top-notch department in my opinion) and am a registered Professional Engineer. I feel equally at home with "charm" quantum numbers or steam tables. My work assignments over the years have almost always been in the general area of applied research, ranging from electromagnetic interference investigations to almost basic research in solid-state physics. Following a personal interest, I have moved into the field of air-pollution control over the past few years. In my studies of atmospheric optics and the behavior of aerosol streams I constantly need many of the things I learned in classical mechanics, electrodynamics, or statistical mechanics. I also find I use what I learned in mechanical and chemical engineering every day. I am certain that there must be many similar situations where physics and engineering intersect and engineering physicists could make an important contribution.

T. G. Stinchcomb (September, page 15) wonders about the equivalency of the training that physicists and engineering-physics majors receive at Oklahoma. I will admit that, partly because I took some classes (such as thermodynamics and mechanics) in the engineering school rather than from the physics department, I did have some problems later in graduate school. But I did overcome them and I would do it again in just the same way. I did learn a lot of engineering in my engineering classes, which has served me well. Stinchcomb also wonders about the job market for engineering physicists. I have found that I generally have an easier time finding openings and am generally offered the same or better salary than friends of mine who are physicists (even though they are mostly brighter than I). I believe that is because employers think that with my engineering training I will produce something they can use (although you and I know that it is the physics I learned that enables me to deliver). There are many fields of applied physics that have been ignored by physics departments. Does your department offer undergraduate classes in physical optics, acoustics, hydraulics, high-pressure physics, and so on? Even without an affiliation to an engineering department, such a hard look at the curriculum would be a good place to start.

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TWT, mags still kicking

I found the article on high-power microwave generation (November, page 18) quite interesting. I was, however, a bit miffed by one statement: "By reviving the old devices (traveling-wave tubes and magnetrons) developed a quarter of a century ago . . . ." I am an engineer working in traveling-wave tube R&D and I would like to inform you that the TWT business is quite healthy with no reviving needed.

TWT's find wide applications in medium and high-power microwave amplifiers. Solid-state devices cannot even approach the kinds of performance we achieve and there is still a lot of exciting R&D going on, some of it even sponsored by NRL. As recently as 1970 an article was published in the *IEEE Transactions*

on Electron Devices presenting a sophisticated nonlinear theory of the traveling-wave tube interaction. I am sure there are also magnetron engineers who would be upset if they heard that someone was "reviving" the magnetron.

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Jobs in college teaching

Readers participating in the college physics-teaching job market might be interested in some observations and results from my year of seeking a job. These are addressed to faculty search committees as well as to applicants for jobs.

During 1975–76 I found about 60 teaching positions to apply to in four-year colleges. These schools variously reported from 100 to 400 applicants for each position, so statistically the chances were not good. Community colleges are apparently not publicizing their positions in many media seen by physics teachers, as I found only about ten positions to apply to in community colleges.

The dignity of applying for a college physics position is being eroded. A few four-year colleges, and most two-year colleges, have application forms to fill out, including questions redundant with the resume, questions inappropriate to college teaching, and some questions that appear to violate stated Affirmative Action goals. Some schools process applications through a central office, and the applicant cannot correspond with the department in which he or she wishes to work. Some schools are still giving red-carpet treatment to visitors, but some cannot provide all travel expenses nor feed visitors.

Approximately 40% of the four-year college positions ask for letters of reference to be submitted with the initial application. Because the job search is long, this procedure eventually fatigues one's referees, and the quality of letters is sure to diminish. I see no pattern as to which schools require letters early. I suggest a uniform policy of requesting reference letters only when a candidate reaches that small group of applicants who are to be invited to visit. I also wonder whether colleges are promptly informing applicants if promised letters and other materials are not being received, so that the applicant may take further steps to complete his application file.

Rather than be unemployed in my profession, I would accept in many cases a half-position. I know of no college offering positions split into two parts so that two people may work where one did before. The increase in productivity would more than compensate the increased overhead.

When I was at the New York meetings and placement service in February 1976, I wondered if the four-year colleges selecting for trained and accomplished physics researchers to do only teaching would be satisfied for long. If only the busy interviewers could have attended the many fine AAPT sessions concerned with improving the teaching of physics! Several years ago when I planned my career in physics education, I had thought great changes in higher education were starting to occur, but progress is much slower than I expected.

The applicant for a teaching position usually receives a rejection in the form of a short mass-printed letter with vacuous and/or ridiculous statements of praise and hope. This is unpleasant, but avoids litigation I suppose. It would be nice to receive brief but explicit feedback as to the nature of the mismatch between position requirements and applicant's qualifications. Many colleges have stated that I do not fill the requirements although I felt I filled every letter of them. More successful applications might result from my knowing more precisely what schools are looking for. Alternatively, better feedback could guide me in altering my career plans.

Finally, I would like to praise the AIP Placement Service for their efficient and very vital assistance to physicists seeking academic positions.

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11/11/76 *Austin, Texas*

Lightning experiment danger

Many readers probably did not realize that in your July issue, figure 2 on page 24 represents a successful and crucial experiment inspired by Benjamin Franklin and installed by Thomas Francois Dalibard at Marly-Le-Roi a few weeks before Franklin obtained similar results with his famous kite. Moreover, in the same issue, John L. Heilbron's very interesting and otherwise well documented article "Franklin's physics" is perhaps somewhat misleading concerning Dalibard's experiment.

My remark is based on the accounts given by most reputable authors (for example, B. Schonland, J. A. Chalmers, H. Prinz) and also on the knowledge gained during our artificially triggered lightning experiments, performed jointly by the Commissariat à l'Energie Atomique, Electricité de France and the Centre National d'Etude des Télécommunications (see *Nature* **257,** 212, 1975).

Heilbron states that wise caution was the reason Franklin did not himself try the dangerous insulated-rod experiment.

In fact, in the light of modern knowledge, it appears that Franklin's kite experiment (curiously not mentioned by Heilbron) was at least as dangerous as the insulated rod used by Dalibard or by G. W. Richmann. The tragic death of the latter must not obscure the fact that among the imprudent amateurs of either technique the number of casualties has been surprisingly low. Nowadays we know that this fortunate situation is related to the observation that static collectors (rods, kites, tethered balloons) usually produce only minor discharges (see M. Brook et al, *J. Geophys. Res.* **66,** 3967, 1961) and the probability of a powerful lightning occurrence is not very high. This observation is confirmed by the fact that the kite string can usually sustain many discharges without damage, in contrast with what is observed when using the rocket and wire dynamic-triggering method.

Heilbron writes "Buffon's agents, sharing Franklin's caution, did not expose themselves to thunderbolts either. They engaged a retired dragoon to draw the sparks." Having myself spent many months in the expectation of conveniently electrified clouds above my head, I am more inclined to believe that this arrangement was dictated by the necessity of conciliating time-consuming scientific research with other social and professional obligations. It is difficult to imagine that Dalibard's experiment would have been repeated in the presence of royal representatives a few days later if any great danger was anticipated.

Nowadays, extensive and costly precautions are required before the safety officers of research institutes give the green light for lightning experiments. These precautions are certainly not superfluous (see *Nature* **260,** 188, 1976) but the eighteenth-century physicists had little possibility of evaluating the danger. The well deserved fame of Franklin is not lessened by the remark that he ran a risk as did other great physicists who pioneered in fields such as x rays or natural radioactivity.

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Teaching physics applications

There have recently appeared several letters on the subject of applied or practical physics. As I believe that this subject deserves much attention and evaluation I would like to add another point of view. The current method of teaching physics to physics majors is to use a lecture–laboratory sequence. In the lecture, basic concepts in physics are discussed, while in the laboratory these principles are made clear. Where we fail is that the laboratory emphasizes the *principles* of physics as opposed to the *application* of physics principles. As a result, many students move through their college education without the feeling of achievement or purpose. They cannot visualize in what way they are developing