15 June 1979 • Vol. 204 • No. 4398

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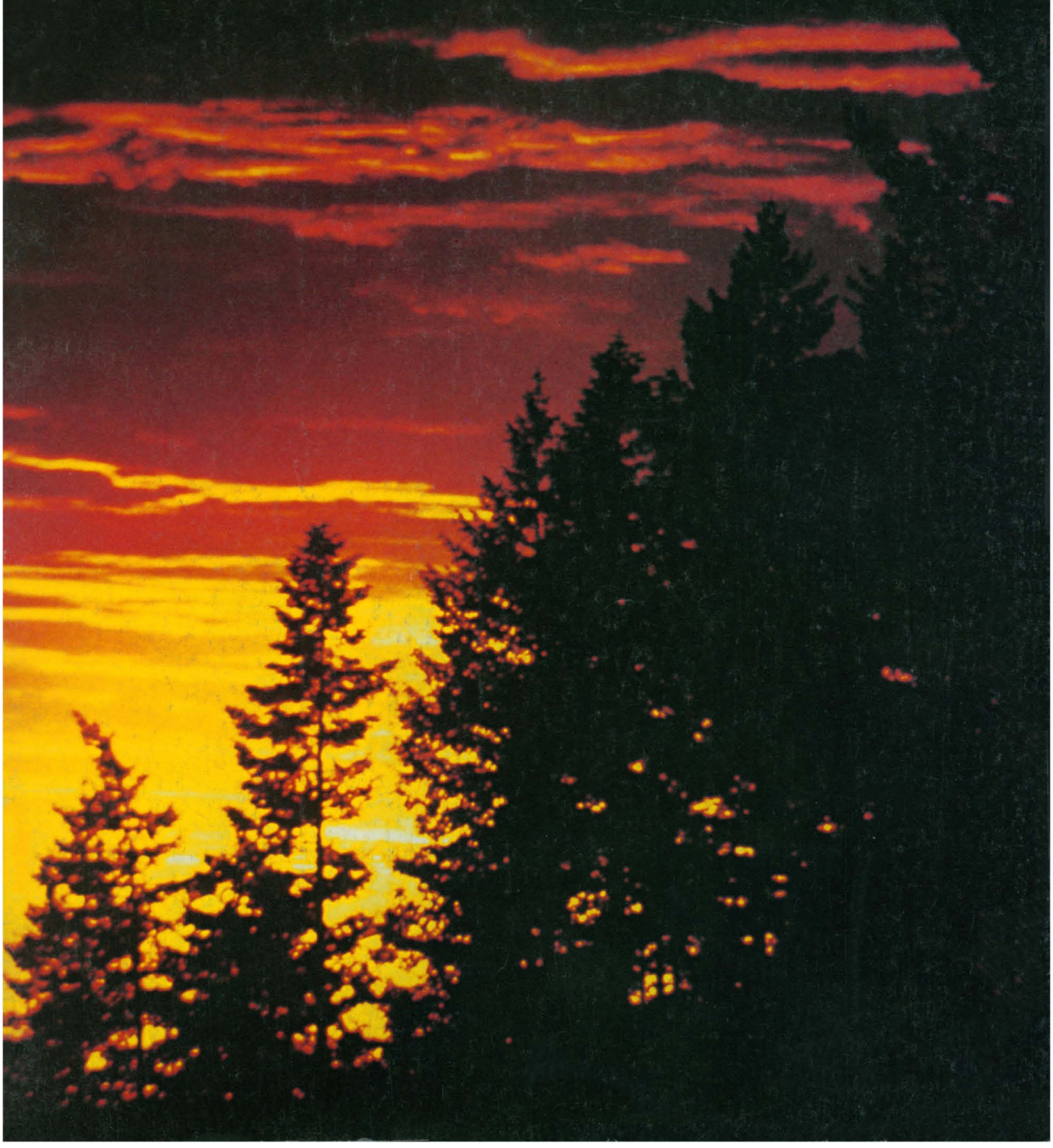

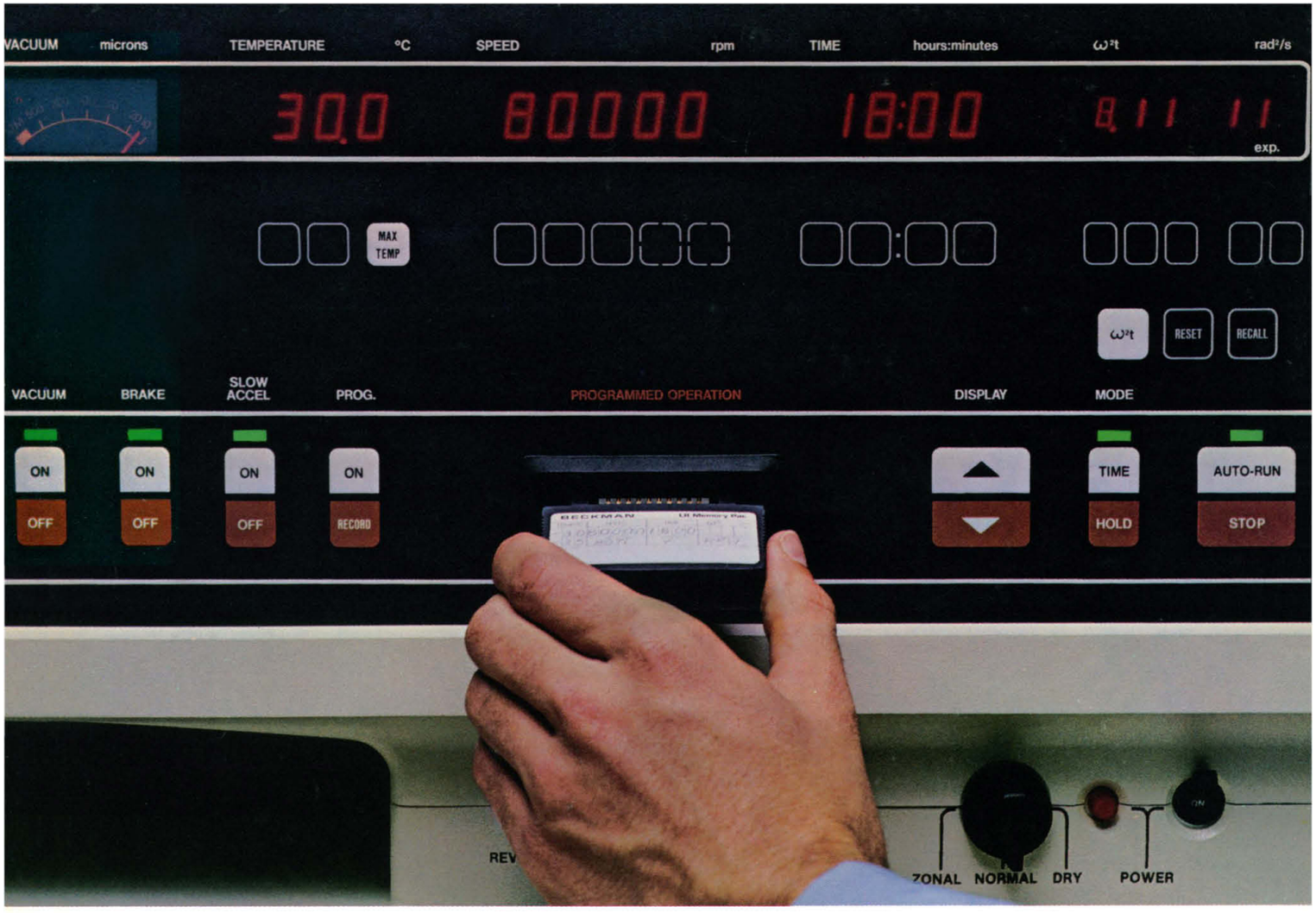

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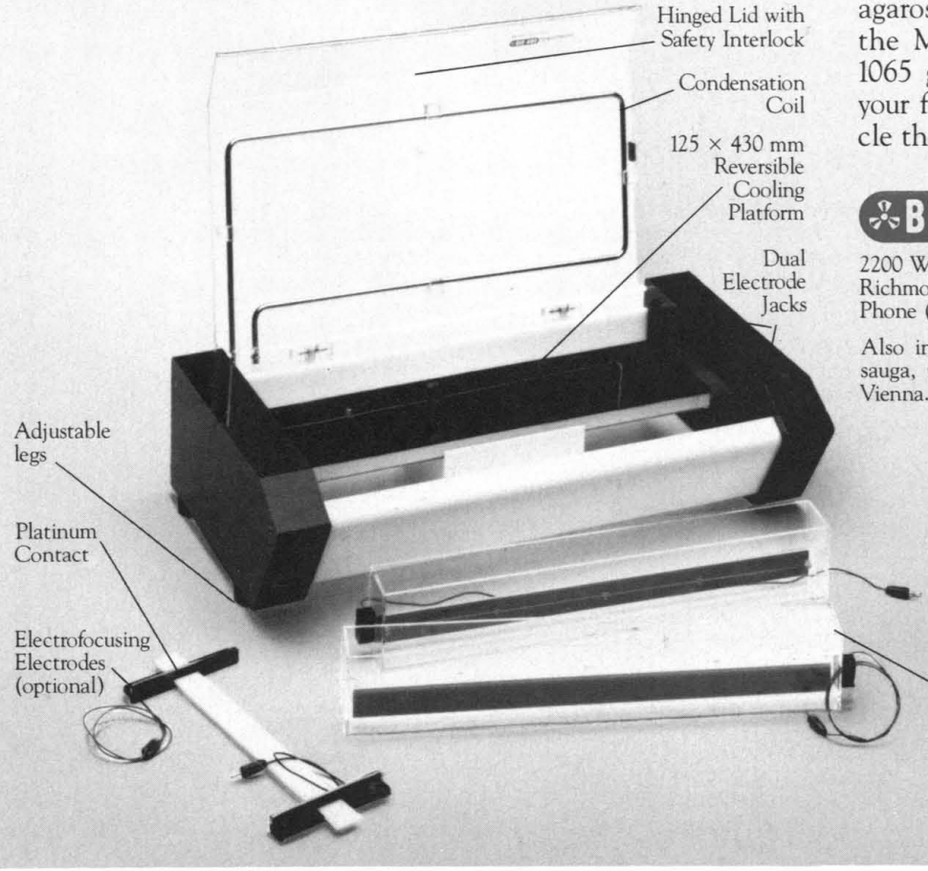

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COVER

American forest. Annual net growth of wood in American forests has increased dramatically in the past 60 years, largely as a result of earlier cutting of virgin forests. The capacity of these forests to grow timber has been consistently underestimated in official reports. See page 1168. [Photograph provided courtesy of American Forest Institute, Washington, D.C.]

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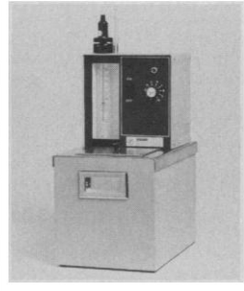

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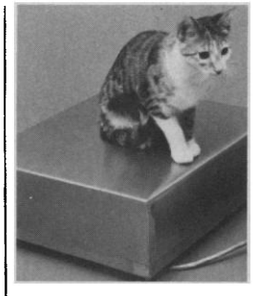

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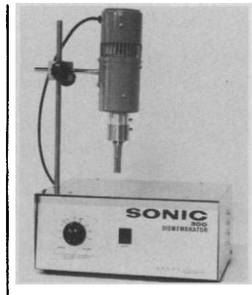

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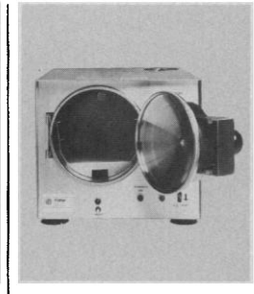

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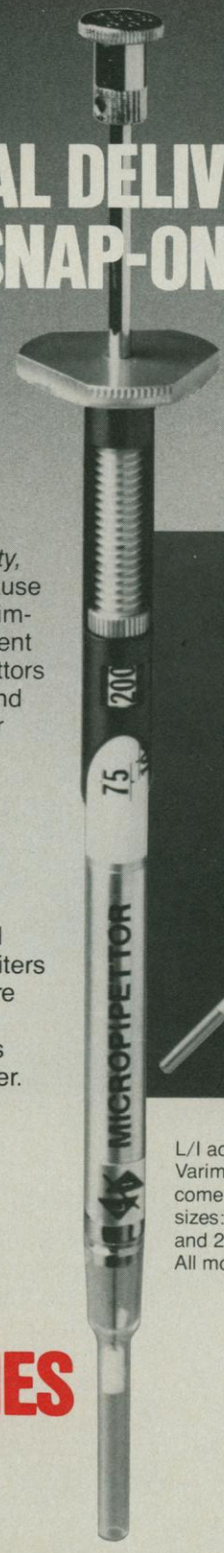

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are five Stay-Clean™ to protect your animals from contamination.

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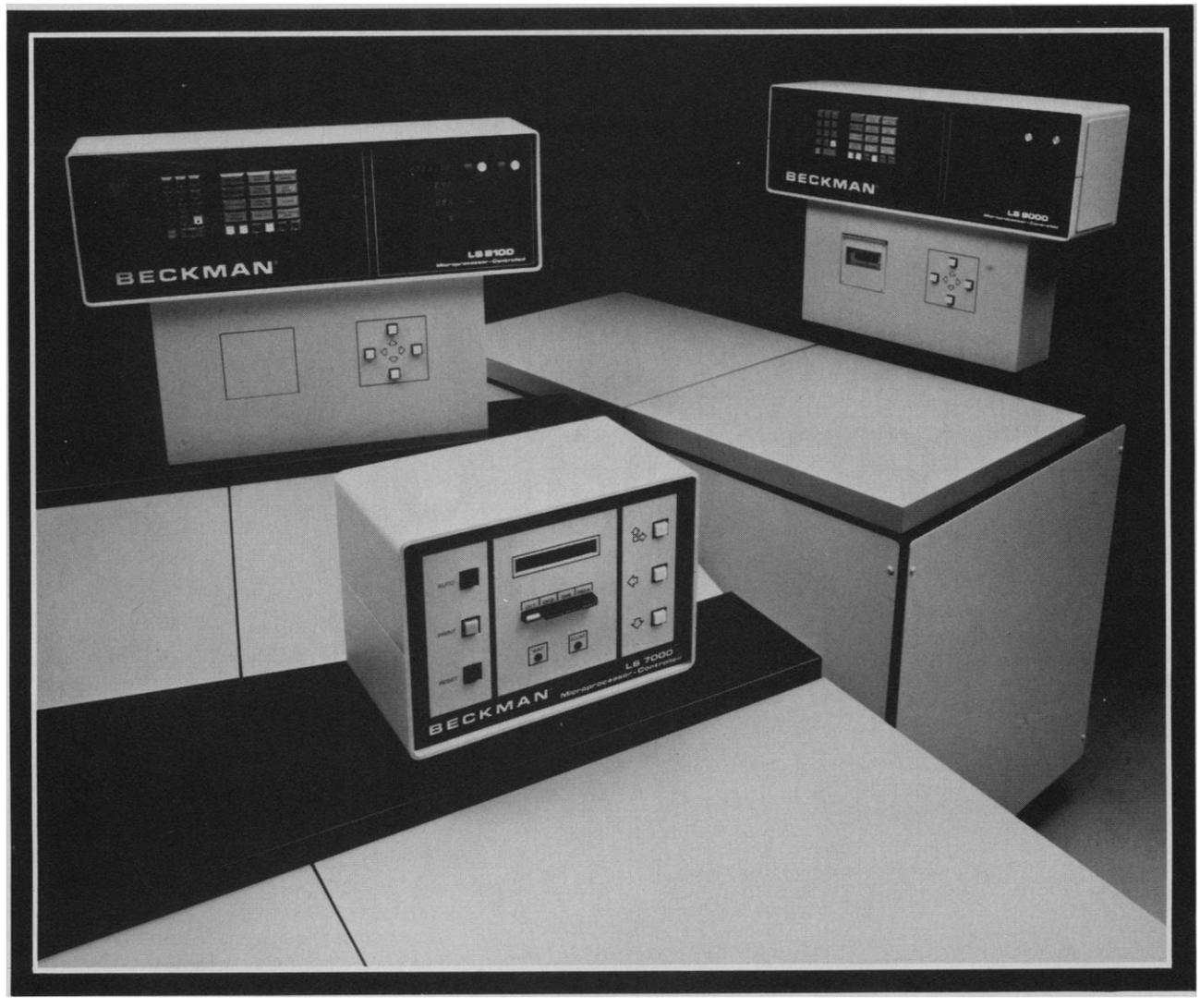

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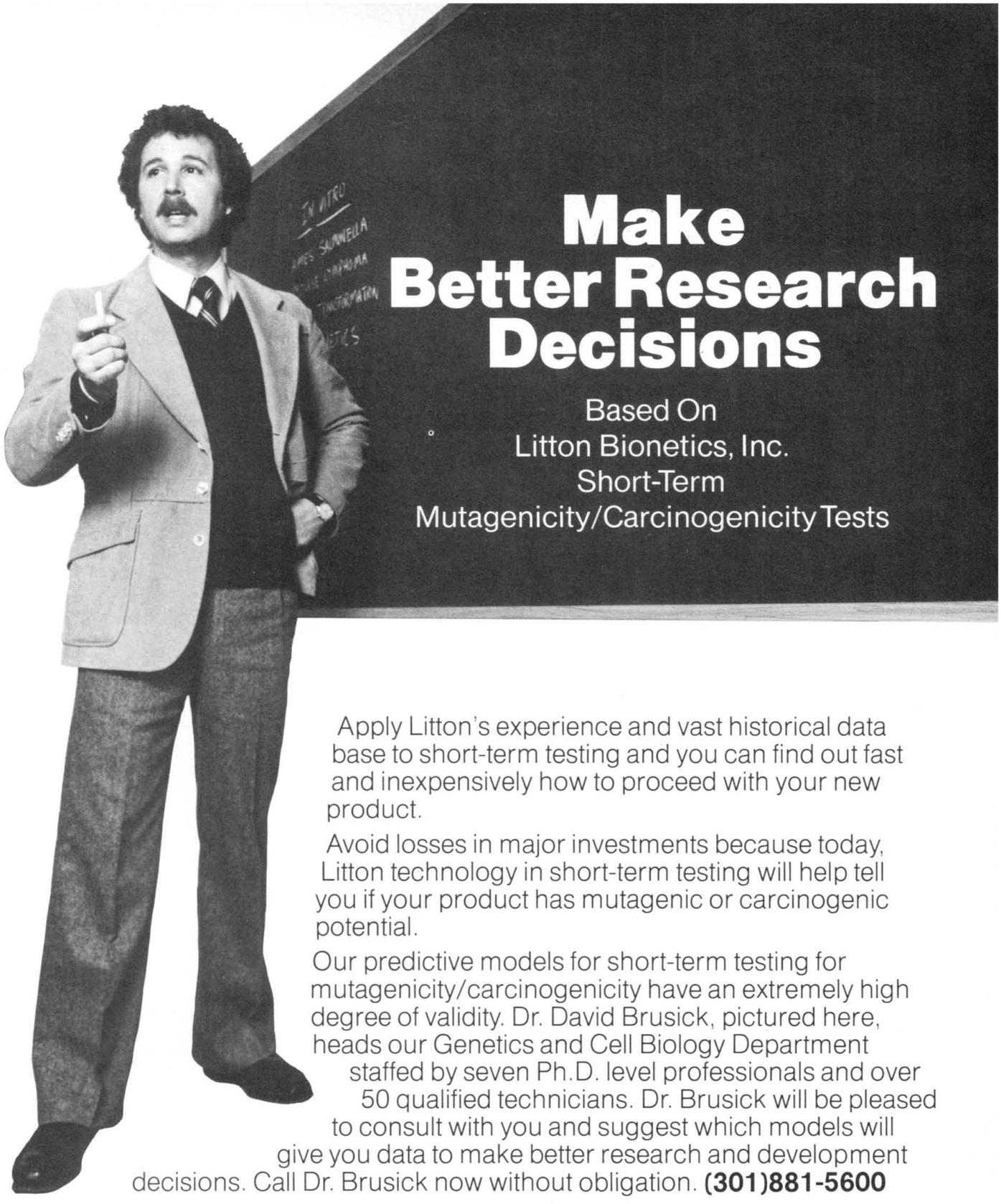

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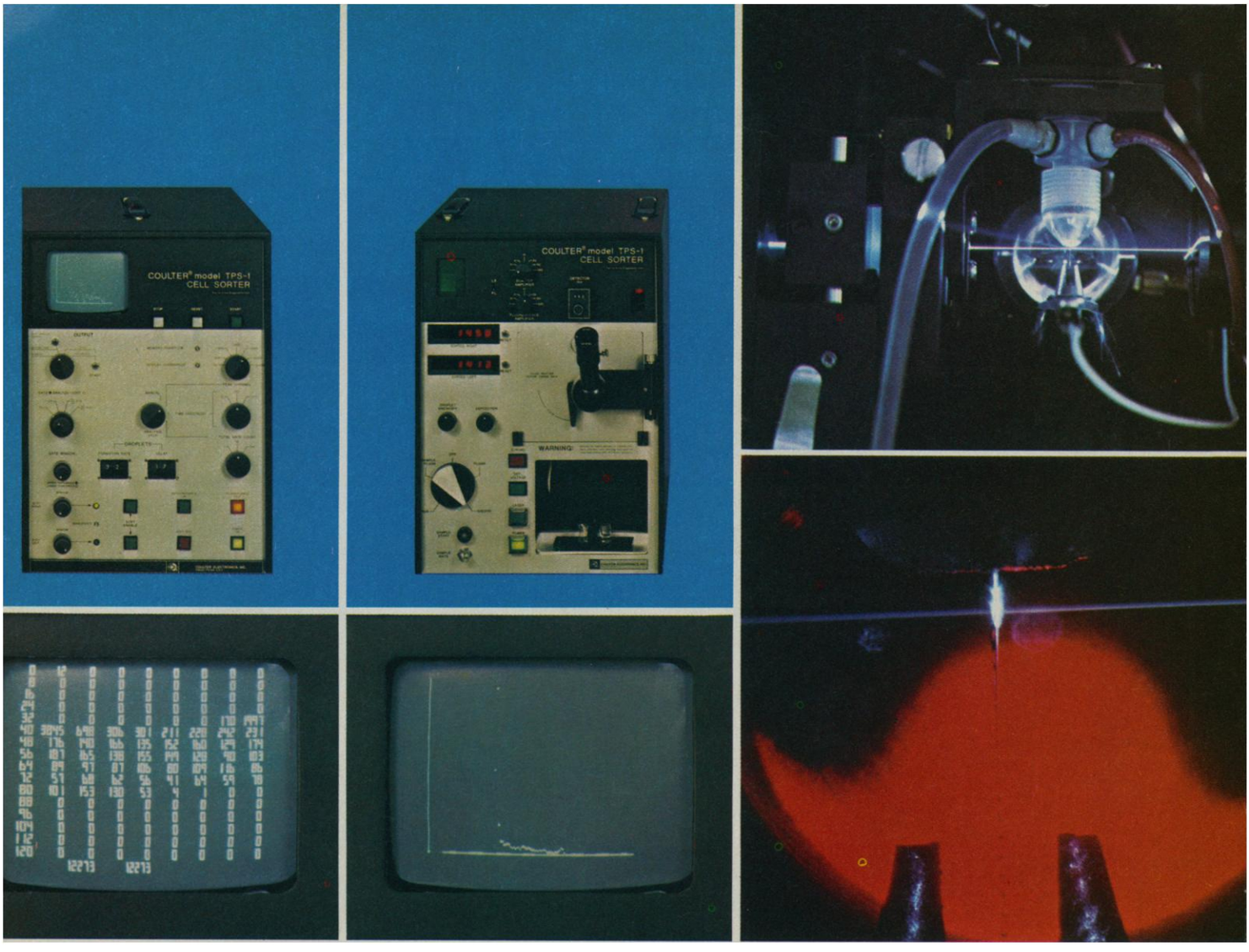

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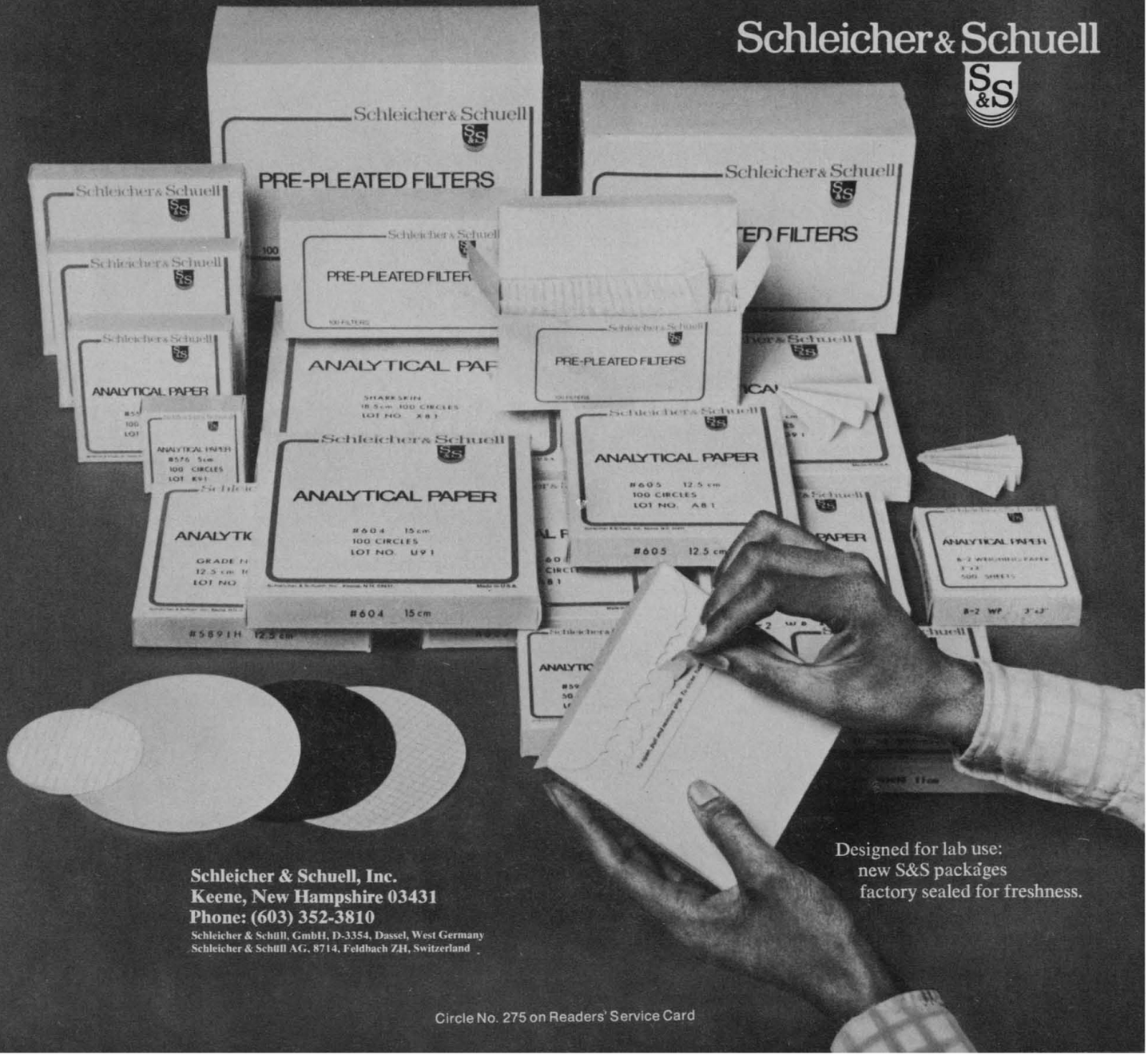

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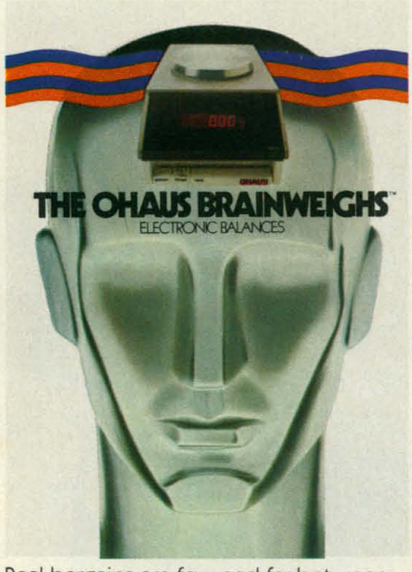

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King Carl XVI Gustav of Sweden—on the right in these photos—presents the 1978 Nobel Prize in Physics to Bell Laboratories scientists Robert Wilson (top photo) and Arno Penzias.

What does the Nobel Prize have to do with your telephone?

The two scientists on the opposite page are receiving the highest honor a scientist can earn—the Nobel Prize. They are the sixth and seventh laureates who did their prize-winning research at Bell Telephone Laboratories. These scientists shared a common goal—the search for new knowledge to further advance the art of telecommunications.

Clinton Davisson shared the Nobel Prize in 1937 for demonstrating the wave nature of matter. In 1956, John Bardeen, Walter Brattain and William Shockley were honored for their invention of the transistor. Philip Anderson's theoretical work on amorphous materials (such as glass) and on magnetism led to a Nobel Prize in 1977. And in 1978, Arno Penzias and Robert Wilson received the Prize for detecting the faint radiation from the "big bang" explosion that gave birth to the universe some 18 billion years ago.

The search for knowledge

These scientists and their colleagues at Bell Labs, given the freedom to explore, have proved time and again the value of investment in research—not only for telecommunications but for society in general. The transistor, for example, revolutionized communications and brought into being entire new industries—indeed, a new industrial society—based on solid-state electronics.

Other Bell Labs advances—products of this same research environment—have included high-fidelity recording, sound motion pictures, long-distance television transmission in the United States, the electrical digital computer, information theory, the silicon solar cell, and the laser. The impact of this work—on almost every field of commerce, industry, education and even medicine—has been incalculable.

The innovation process

Research done at Bell Labs in the past is the basis for the products and services the Bell System offers its customers today, just as the research going on now is the foundation for tomorrow's telecommunications.

Bell Labs scientists—specialists in physics, chemistry, mathematics and many other disciplines—team their efforts with those of our systems, development and design engineers. They, in turn, work closely with Western Electric manufacturing engineers and with the people of the Bell System operating telephone companies.

This technical integration is the foundation for true innovation. One idea feeds another. A basic scientific discovery can make possible entire new technologies and products for telecommunications, and a concept for a new product or system can stimulate the research to find even more new knowledge. That interaction, that teamwork, has been extremely productive: Bell Labs people have received 18,645 patents between our founding in 1925 and the end of 1978.

Sometimes, the search for knowledge may lead to a Nobel Prize. Often, it benefits all of society. And always, its ultimate aim is better service for Bell System customers.

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LETTERS

Risk Accounting

It seems to me that there is cause for concern that the recent flurry of letters (4 May, p. 454; 11 May, p. 564) attacking the recent article by Inhaber (23 Feb., p. 718) will cause readers of *Science* to lose sight of the fundamental methodological change in risk accounting proposed by Inhaber, namely that one should charge for those risks incurred in the acquisition of materials of construction and the construction of the facility. In fact, this aspect of risk accounting has not generally been included previously. Had it been, we would not have read a continuing series of scientific and public pronouncements in the past that solar energy is benign, either ecologically or from the point of view of health and safety. No energy source is. Just think about the pollution from copper mines and smelters when you consider a technology that needs copper.

I myself have had questions about some of Inhaber's data and results, as have had others. More detailed and accurate studies are needed to confirm or negate his general results than have been afforded by the letters of criticism. Whatever the eventual results, he has made an important contribution to our thinking.

I also question two of Lemberg's criticisms (4 May) of Inhaber's method. I find no basis for charging only incremental risks connected with material acquisition, as proposed by Lemberg. If a coal miner is killed in a coal mine accident, we don't say, "But he might have been killed constructing some skyscraper" when we count the risks from coal-generated electricity.

Second, society cannot exist only with energy systems subject to daily or other frequent loss of all or most generating capacity. There must be storage or backup systems, and a proper risk accounting has to include a charge for this aspect of an unsteady supply source. Lemberg might have suggested that Inhaber should have used the risk corresponding to the average societal energy mix rather than that due to coal, which Inhaber estimated to have the highest risk. Or Lemberg should have proposed less risky backup.

In his risk accounting, Inhaber did not allow for one potentially important aspect. If society spends $1 billion a year more to make electricity, it does not have that billion dollars to improve the health and safety from whatever risks provide the greatest risk reduction potential per dollar expended. If one could "save" a life (defer a premature death) by expending $200,000, a billion dollars per year saved by use of a cheaper energy source could enable the "saving" of 5000 lives a year. This contribution to risk accounting could be dominant if there is a major disparity in costs of energy among various sources.

DAVID OKRENT
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French Anti-Nazis

As one who spent the war years in occupied France working with the Underground, I strongly disagree with Joan Bromberg's statement (18 May, p. 741) in her review of *Scientists in Power* (*1*) that the most active French anti-Nazi group was the Communist Party. The Communists were latecomers to the movement, siding with De Gaulle and the Resistance only after Germany attacked Russia in June 1941. At that time political and religious considerations mattered much less than individual commitment against oppression; the spectrum ranged from right to left and from fundamentalism to atheism. Furthermore, the raised fist in the accompanying photograph was not the Communist salute but that of the Popular Front, which, besides the Communists, included socialists like Pierre Cot as well as Centrists like Prime Minister Daladier.

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References

1. S. R. Weart, *Scientists in Power* (Harvard Univ. Press, Cambridge, Mass., 1979).

Proposals, Peer Review, and Research Results

The rapidly worsening nature of the processes used in the funding of research is receiving increasing if belated attention. A recent editorial by Philip H. Abelson (13 Apr., p. 133) highlights one important aspect of the situation (aside from the universal complaint of lack of money), namely the serious drop in morale among scientists. But, if the situation is to improve, the scientific community must do much more than complain. I believe that the universal solvent of "more money" (legitimate as such

requests may be) has so befuddled our intellectual capacities that the scientific community shares with the government the responsibility for the present situation.

It all starts with sloppy science and ends in an administrative "Cuckoo's Nest." The doctrinaire pernicious nonsense that the only or best way to support science in all times and circumstances is through elaborate, peer-reviewed, proposal mechanisms was spotted long ago by Leo Szilard (Editorial, 16 Feb., p. 607). His criticism has never been rebutted. The present system is still, regrettably, taken as gospel by a good fraction of the postwar generation of U.S. scientists, the following facts notwithstanding:

- Many of the premier U.S. agencies supporting research (for example, the Office of Naval Research and the Defense Advanced Research Projects Agency) have never used it.
- Entire nations seem to manage without it.
- The efficiency of the process in terms of scientists' energy used in doing research over the energy used in obtaining money and doing the research, is now between 66 percent and 50 percent. And it is this system which everyone complains about.
- The psychological damage to the body of science in terms of morale, almost "encouraging" dishonesty, and so forth, may be the most serious flaw in the system.
- Historians of science record that great science is built around key individuals, small groups, or a special "bunch of people," in Lewis Thomas' felicitous phrase, not around elaborate proposals.
- In simple English, performance (that is, the track record) is a much better guide to success than promise (that is, proposals).

Unless one is prepared to change this system in a major way, I believe that complaining about it is futile. Money cannot help this situation, any more than additional gasoline can fix a flat tire.

Nearly 10 years ago it was an experienced congressman, not any science group or scientific body, who proposed a major change. In the 91st Congress, George P. Miller, veteran chairman of the science, research, and development subcommittee, introduced a bill, HR35, in which he proposed a complex "formula" to allocate research money to universities. A divided academic community managed to head it off.

Things are different today. I, too, have sampled some 20 outstanding "successful" research group leaders with the proposition: "Would you take 75 percent

of the total basic research support your laboratory now has if you wrote only one annual report-proposal, and your funding became a complex, slowly adjusting function of the number of graduate degrees, the number of papers published (and possibly the amount of *mission agency* support you received)?" All of them said they would take the formula even at the cost of a 25 percent cut.

No one unfamiliar with the literature should dismiss the "formula" basis as unable to take care of most situations, including new investigators or playing into the old-boy network. Exactly the opposite is true in both cases. In an era when nondirected academic research support is quite unlikely to receive a significant increase in funding, science unions could, for a change, go to the bargaining table accepting even a 5 percent cut in (real) pay in exchange for a major change in "working conditions" for their members.

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Quality of the Social Sciences

The excellent editorial by William D. Carey (20 Apr., p. 259) illustrates how far we still must go before the social sciences can achieve legitimacy. The congressman who said that philosophers and thinkers have been contemplating social phenomena for centuries without National Science Foundation support and have been able to reach far-ranging conclusions without wasting tax dollars is not alone. The political elites of the world, like their general publics, have only a dim understanding of what social scientists do. Worse yet, few appreciate that reliance on conventional wisdom contributes to many of our social disasters and that research-generated knowledge could appreciably reduce our error rate.

The most effective response to this widespread ignorance and disdain is a clear-cut improvement in the scientific quality of our research, as well as increased attentiveness to its social relevance. Books and journals in the social sciences are brimful of material that makes researchers shudder and laymen laugh, and it is high time that we pulled up our socks and got more serious about how we design, conduct, and write up our work. On top of that, we had better take our teaching more seriously, too. The people who run the world have all sat through social science courses in the

universities, and it is reasonable to infer some connection between the quality of *our* teaching and the quality of *their* understanding. If we are cavalier about our methods, careless with our concepts, and condescending to our students, we can hardly expect rapt and reverent attention to our work later on.

Another factor that contributes, albeit less directly, is that of labeling. Too many of us still use such dichotomies as the exact sciences versus the social sciences, or the natural sciences versus the social sciences, thus acquiescing in the dubious propositions that our research is inherently less exact and our subject matter less natural. Why not use the more accurate and nonpejorative trichotomy of the physical, the biological, and the social sciences? Finally, we might want to use the word "theory" more carefully. If *we* fail to distinguish between a body of codified knowledge on the one hand and an ill-assorted set of hunches on the other, how can we expect the public to appreciate the difference?

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East Is East . . .

In the debate on the future of the nuclear weapons laboratories, if the "changing conditions" described by Secretary of Energy Schlesinger include a move of the Livermore laboratory to a site 35 miles *west* of Berkeley, as reported (News and Comment, 4 May, p. 481), every effort should be made to find funds to keep the lab afloat.

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Government-University Relations

The National Commission on Research was established in October 1978 to deal with mounting concern over the deterioration of the government-university relationship and its impact on research. Six national organizations assisted in establishing the commission: the National Academy of Sciences, the Social Science Research Council, the American Council of Learned Societies, the American Council on Education, the Association of American Universities, and the National Association of State Universities and Land-Grant Colleges. We are, however, an independent, nonprofit corporation financed primarily by private foundations. We work in cooperation with the establishing organizations but are administratively and financially separate from them. The membership is comprised of 12 leaders in education and industry who have accepted appointments as unpaid commissioners, with William H. Sewell as chairman. We have no federal officials on our commission, but we have instituted a network of liaison officials in the principal mission agencies responsible for carrying out university-based research programs and in the administrative agencies responsible for proper management of these federal activities. Through a process of hearings, review of existing studies and materials, limited data gathering, and extensive consultation with officials of universities, associations, and government, the commission will examine the means by which federal support of university research is conducted and propose changes to improve this system. The commission holds monthly meetings in Washington or on selected university campuses. It plans to issue a series of short reports on topics within its purview, focused particularly on recommendations. Advocacy for increased funding is not a direct role of the commission.

Comments on any aspect of the government-university relationship for support of research are invited. We have identified several areas of focus.

- Scientific, administrative, and fiscal accountability.
- Peer review and other selection criteria.
- Alternative funding mechanisms and instruments.
- Industry/university/government relationships.
- Development of research personnel, including young investigators and nontenure track faculty.
- Extent of agency involvement in technical monitoring, control of research, and the publication process.
- Political and social factors affecting publicly supported research, and the environment required for research to flourish.

Any studies of these or related issues would be extremely useful to us. We are also interested in specific examples of difficulties encountered in these areas, and particularly suggestions for improvements of general applicability.

CORNELIUS J. PINGS
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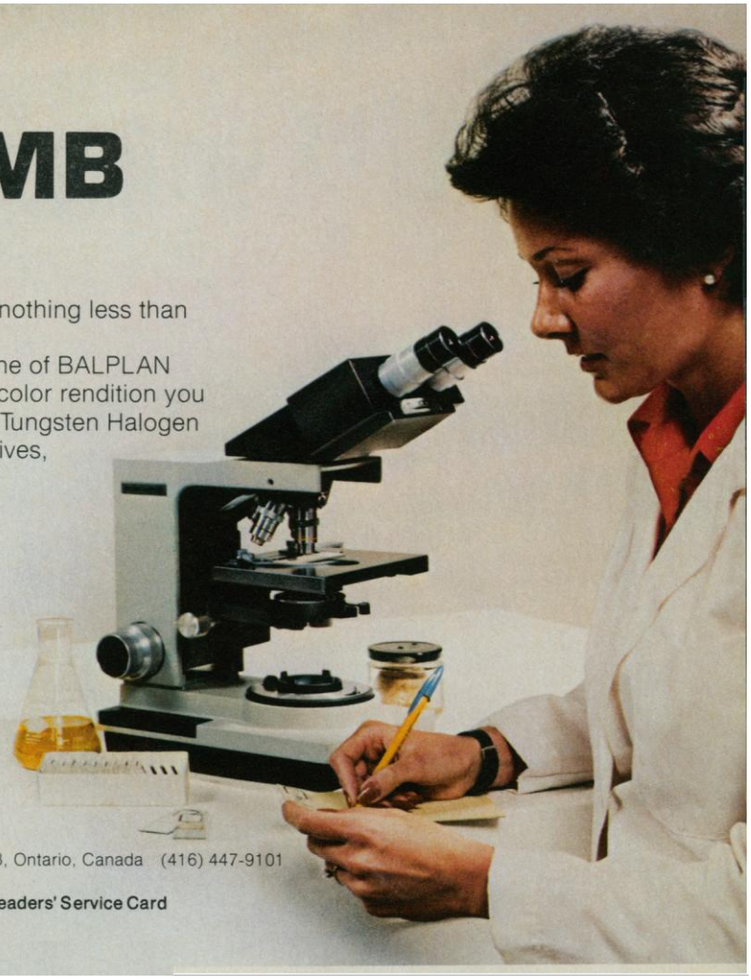

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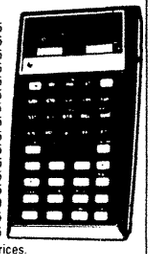

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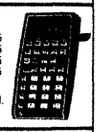

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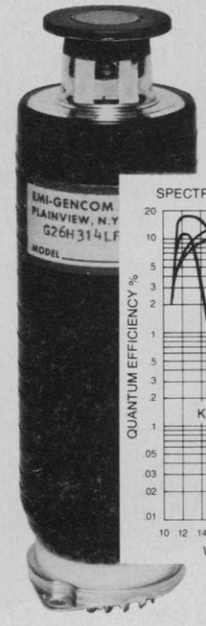

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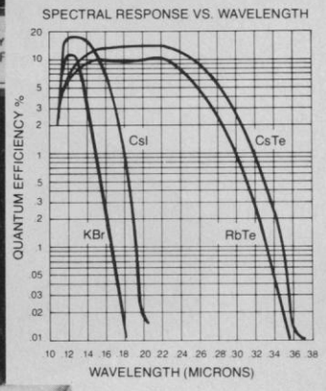

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15 June 1979, Volume 204, Number 4398 **SCIENCE**

Bio-Energy

Scientists and engineers will share the energy shortages that the public will endure for the next decade or two, but with a difference. They are problem-solvers, and they are in a unique position to help satisfy energy needs. Already many are exploring promising areas. Some are working to expand the availability of energy derived from materials formed by photosynthesis. The extent and variety of these efforts are not generally known. But a large fraction of the federally supported and many of the privately financed activities are described in a recently released *Bio-Energy Directory.** In this volume of 539 pages, nearly 500 projects are noted. Topics treated include fundamental studies on photosynthesis, sources of biomass, and methods of converting biomass to other forms of energy.

Ultimately, perhaps half of the nation's energy will be provided via photosynthesis and subsequent conversion of its products. Attaining such a goal will not be easy or quick. The best land is already being used to produce food, fiber, building materials, and paper products. In addition, current energy consumption is enormous. Even if the total harvest of corn grains were fermented to alcohol, the liquid would provide only one-eighth of current gasoline demand. Hunger around the world will tend to limit the amount of grain that can be diverted to energy. Useful supplies of energy are being obtained from agricultural, forest, and urban wastes, but these sources are not likely to supply more than a minor fraction of total demand. However, in many instances, conversion of wastes serves the double purpose of producing energy and diminishing pollution.

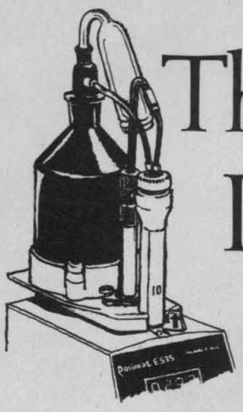
The crucial opportunity for obtaining additional energy supplies lies in expanding the useful output of biomass. This can be done by genetic improvement, better management and choice of species for a given area, cultivation of plants for production of hydrocarbons, and utilization of land and marine areas not currently harvested. Progress is being made along all these lines. Forest product companies say they have already doubled yields on some land through selection of trees and better management. Projects in different sections of the country are assessing local vegetation.

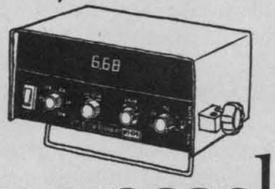
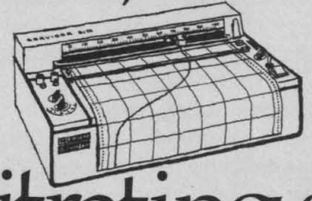
An intriguing concept is to foster vegetation that yields hydrocarbons. The practice of obtaining hydrocarbons from trees has a long history. Oleoresins have been tapped as a source of turpentine for many years. Natural rubber has been used for more than a century. It is superior to the synthetic variety. The desert plant guayule produces a latex whose principal component is identical to that obtained from trees. Another desert plant with interesting potential is jojoba, which yields nuts that contain a valuable oil. Melvin Calvin is enthusiastic about producing hydrocarbons from a species of *Euphorbia*. He speaks of getting the equivalent of 10 to 20 barrels of oil per acre from "petroleum plantations."

It has been said that "wood is too valuable to be burned," and it is unlikely that most wood will be used that way. Instead, major efforts will be made to convert wood to valuable chemicals and liquid fuels. One of the principal means will be use of microorganisms. Fermentation microbes can be chosen that produce high yields of specific substances. At one time, the United States obtained its industrial alcohol, acetone, and butanol from fermentation of glucose derived from starch. Much effort now is being directed to obtaining chemicals from cellulose, which is also a polymer of glucose. A major goal is effective conversion of wood. This is not easy, because wood has a complex structure that involves cellulose, lignin, and hemicellulose. The *Bio-Energy Directory* lists a number of projects in which this crucial problem is being addressed.

In the United States, energy from biomass will face competition from other sources such as coal and oil shale. But should the CO_2 problem loom large, it will be essential to have available renewable energy sources that do not produce a greenhouse effect.—PHILIP H. ABELSON

**The Bio-Energy Directory*, Bio-Energy Council, 1625 Eye Street, NW, Washington, D.C. 20006; $30 through 31 July, $40 thereafter.



The Metrohm pH Stat Titrator. It gives you self-refilling burets, a removable digital pH Meter,  quick-release  titration vessels, finger tip setting of stat point  or end point, and a multirange recorder,  all in the same pH stat titrating system.

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