# SCIENCE

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE


ALASKAN ISLAND

Report from

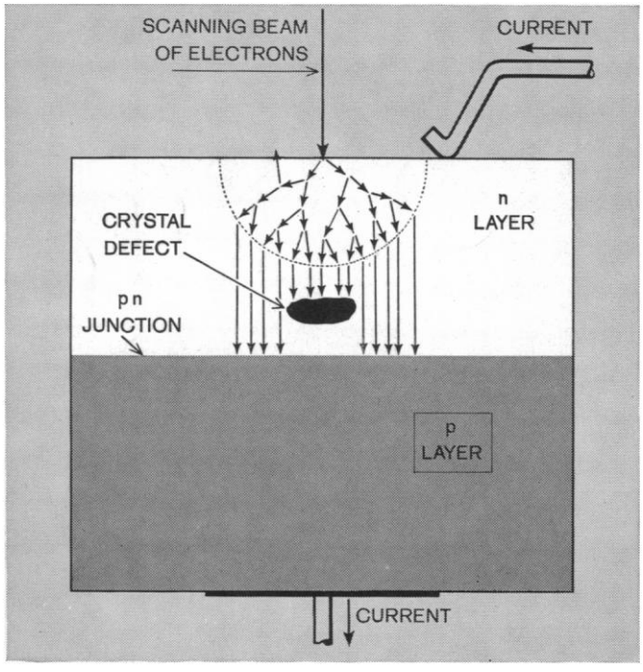
**BELL LABORATORIES**

# New type of microscopy reveals internal structures of crystals

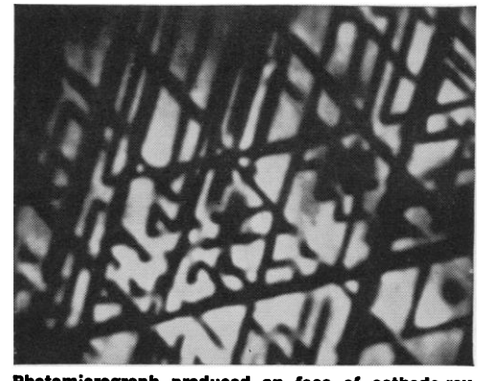
Bell Telephone Laboratories scientists have developed a new type of microscopy that uses a beam of electrons as a probe to investigate the structures of semiconductor crystals. Unlike other electron-probe arrangements or the electron microscope, which are limited to studies of surfaces or very thin layers, the new system is used to reveal features within the body of the semiconductor.

As shown in the drawing below, crystal defects are not probed directly by the electron beam. Instead, the secondary charge carriers created by the beam are used, in effect, to project an image of each imperfection onto the plane of a pn junction. This image is then reproduced on a cathode-ray tube. The process is nondestructive of the crystal, usually does not require special treatment of the crystal surfaces, and has a resolving power higher than that of optical microscopes.

This new type of microscopy reveals both surface and internal structure and allows separate identification of each. It has proved useful in studying crystal defects that may degrade the performance of semiconductor diodes and is also leading to greater understanding of crystalline structures.




**Mechanism of new type of microscopy developed at Bell Telephone Laboratories: Beam of electrons is directed onto surface of semiconductor crystal containing pn junction and penetrates crystal a short distance (vertical distance here is exaggerated). Beam creates a "cloud" of secondary electron-hole pairs, indicated by the semicircle of dots. Normally the created charge carriers are collected by the pn junction, giving rise to diode current. If the beam is swept across a crystal defect, however, the diode current drops, apparently because the tendency for electrons and holes to recombine is heightened in the vicinity of the defect. Thus the defect casts a "shadow" on the pn junction. The surface of the crystal is scanned by the electron beam in a series of lines, TV-fashion. The varying diode current, displayed on the face of a cathode-ray tube, results in "pictures" of the defects in the vicinity of a junction. In such pictures (right) the crystal defects appear as dark lines or regions.**



**Photomicrograph produced on face of cathode-ray tube by new technique. Dark lines show regions of crystal imperfections resulting from strain introduced by diffusing phosphorus into surface of silicon. (620X magnification.)**

**Large dark areas are regions of crystal damage caused by mechanical indentations in surface of silicon. Heat treatment relieved strain and caused edge dislocations, seen here as radiating lines or arc segments, to move outward from strained region. (800X magnification.)**

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# SCIENCE





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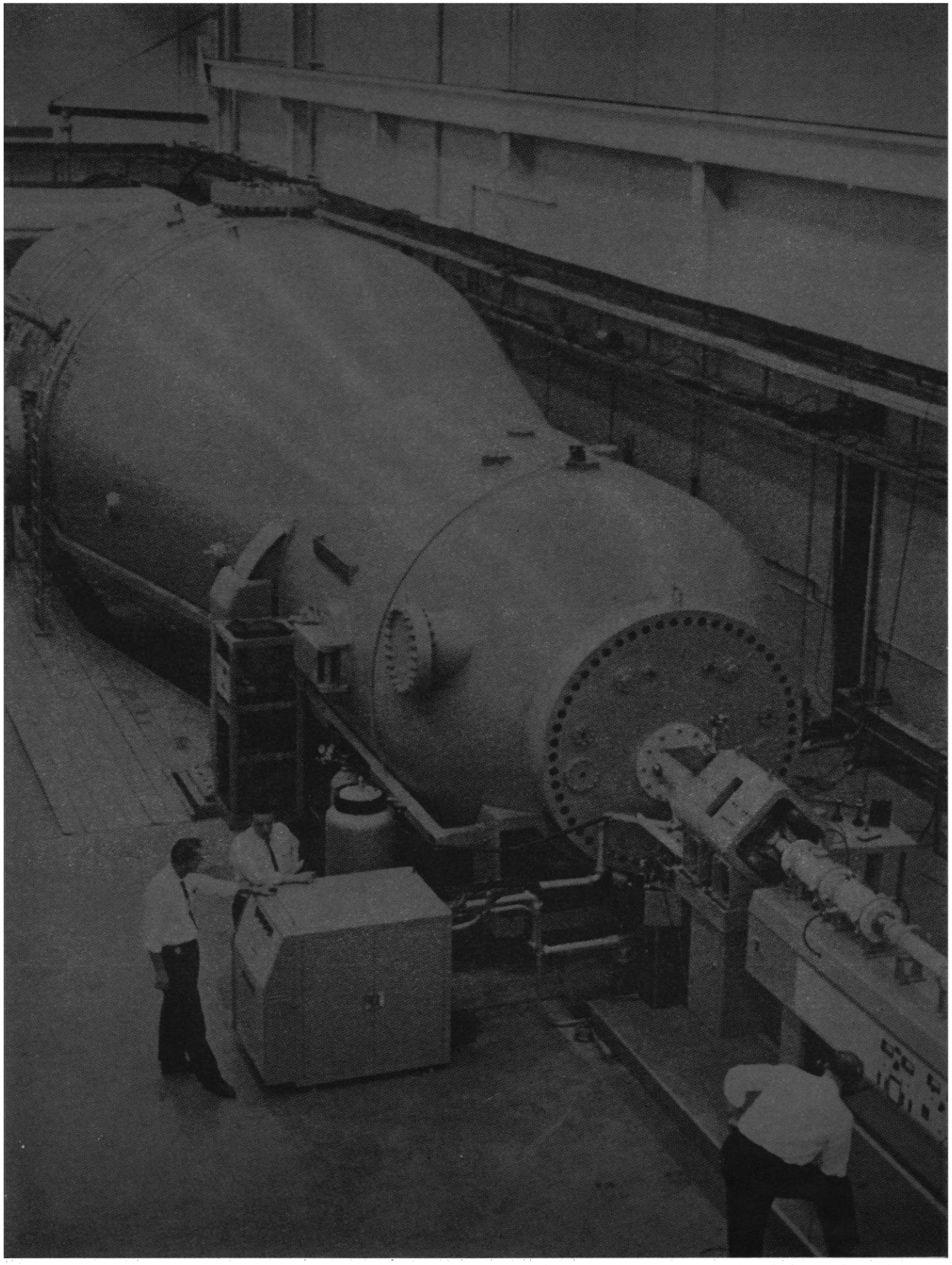
**COVER**

Sand dunes on St. Paul Island, Alaska, from an altitude of 400 meters. The island, a member of the Pribilof group, lies near the southwestern edge of the continental shelf extending between Alaska and Siberia. Because of its location the island can provide a record, as to time and environment, of former land connections between Asia and North America. See page 343. [Victor B. Scheffer and Karl W. Kenyon, U.S. Department of the Interior, Seattle, Washington]



MP Tandem Test Facility at High Voltage Engineering Corporation.

## New opportunity for heavy element research:

# Uranium ions accelerated to 200 MeV by HVEC Emperor Tandem

Uranium ions have been accelerated to record-high energies exceeding 200 MeV during heavy-ion performance tests of the first completely assembled Model MP "Emperor" Tandem. The tests were carried out at HVEC's MP Tandem Test Facility at Burlington.

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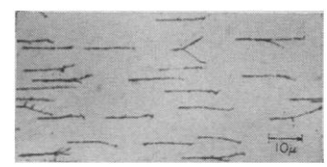
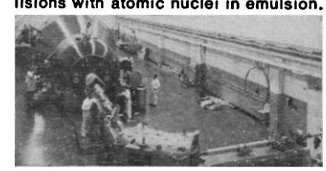
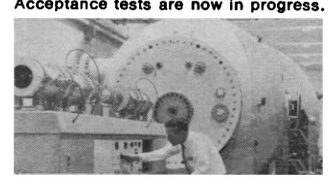
A new booklet describing the MP heavy-ion performance tests contains a number of very interesting photomicrographs of recorded particle tracks. For a free copy and detailed information about HVEC particle accelerator systems and components, write to our offices at Burlington, Massachusetts or Amersfoort, The Netherlands.



500X photomicrograph of uranium ions accelerated by MP Tandem striking photographic emulsion plate at 10 degree incidence. Note frequent collisions with atomic nuclei in emulsion.



MP Tandem accelerator being installed at Yale University has accelerated proton beams of 20 microamperes in the range from 10 to over 20 MeV. Acceptance tests are now in progress.



MP Tandem accelerator being installed at Atomic Energy of Canada Ltd. Chalk River Laboratories achieved 15 MV terminal voltage during initial test of the electrostatic structure.

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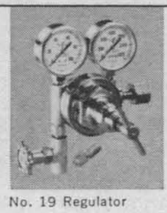
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☐ **BIOLOGICAL MECHANISMS OF AGING** *by* **Howard J. Curtis,** *Brookhaven National Laboratory, Upton, N. Y.* March '66, 148 pp., 22 il., (Amer. Lec. Living Chemistry edited by I. Newton Kugelmass), $6.50

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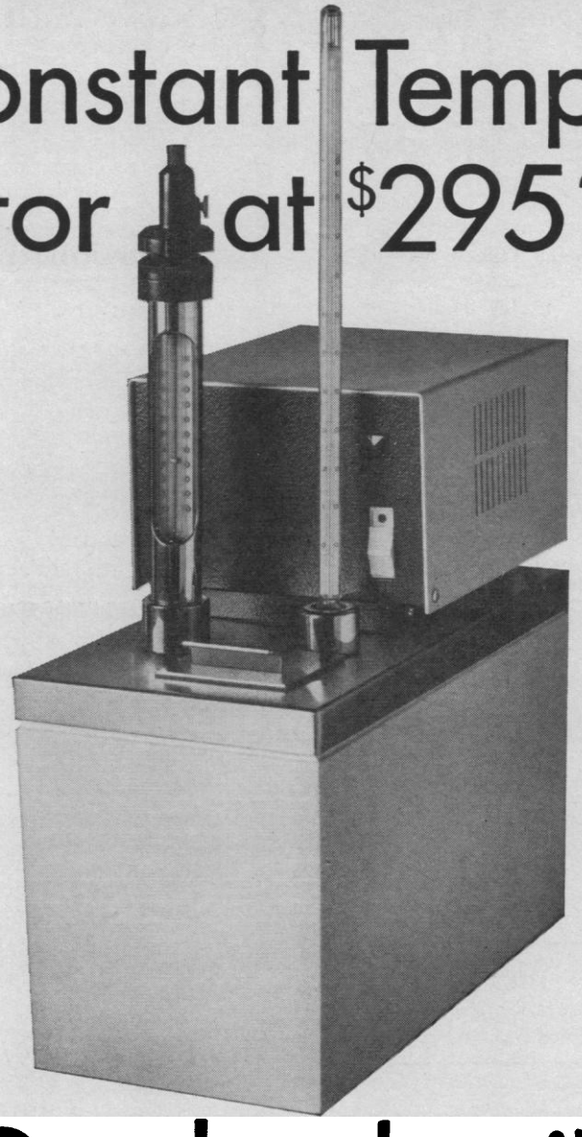

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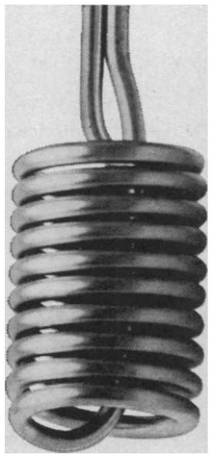

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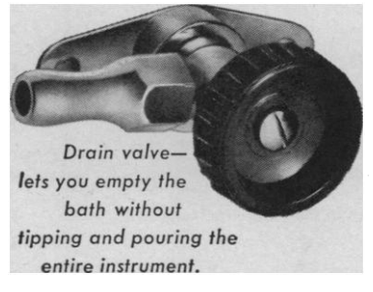

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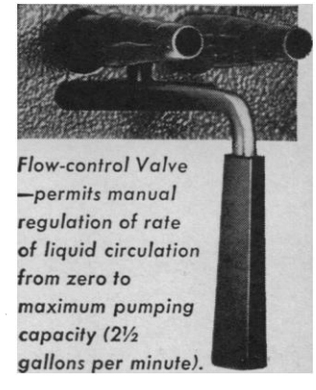

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W. I. FOLLETT
*Department of Ichthyology, California Academy of Sciences, San Francisco 94118*

## NSF: Initiative in National Policy

Greenberg's discussion of a House subcommittee's report on the National Science Foundation ("Daddario study says NSF should be in the forefront of policymaking," News and Comment, 14 Jan.) brings into focus what to me is the most remarkable feature of NSF funds: their availability to those who wish to test hypotheses previously untested or misinterpreted but still worthy of further study. NSF is a reserve that can be drawn on by those whose minds are open to the multitude of physical and biological systems yet to be explored. It is a monument to the belief that one should not have to be born rich in order to engage in learned pursuits of one's own choosing that further man's knowledge and welfare. The soundness of this philosophy has already been demonstrated. We need now to safeguard its future. The fact that the distribution of funds differs markedly from ancestral custom need not be alarming. We can be confident that better use of the funds will be made by allocating them to creative men who come forward with proposals than by the age-old system under which a few persons decide how funds should be spent and then search for someone to pursue that course.

At present scientists seem to be in a very favorable position of trust. . . . As NSF now stands, it is a tribute to both science and management. It demonstrates to the researcher that his course is acceptable to his fellow men, and to managerial authority that scientists have confidence that their needs will be met in the general economy. For these reasons it is to be hoped that NSF will not be required to enter the competitive political arena.

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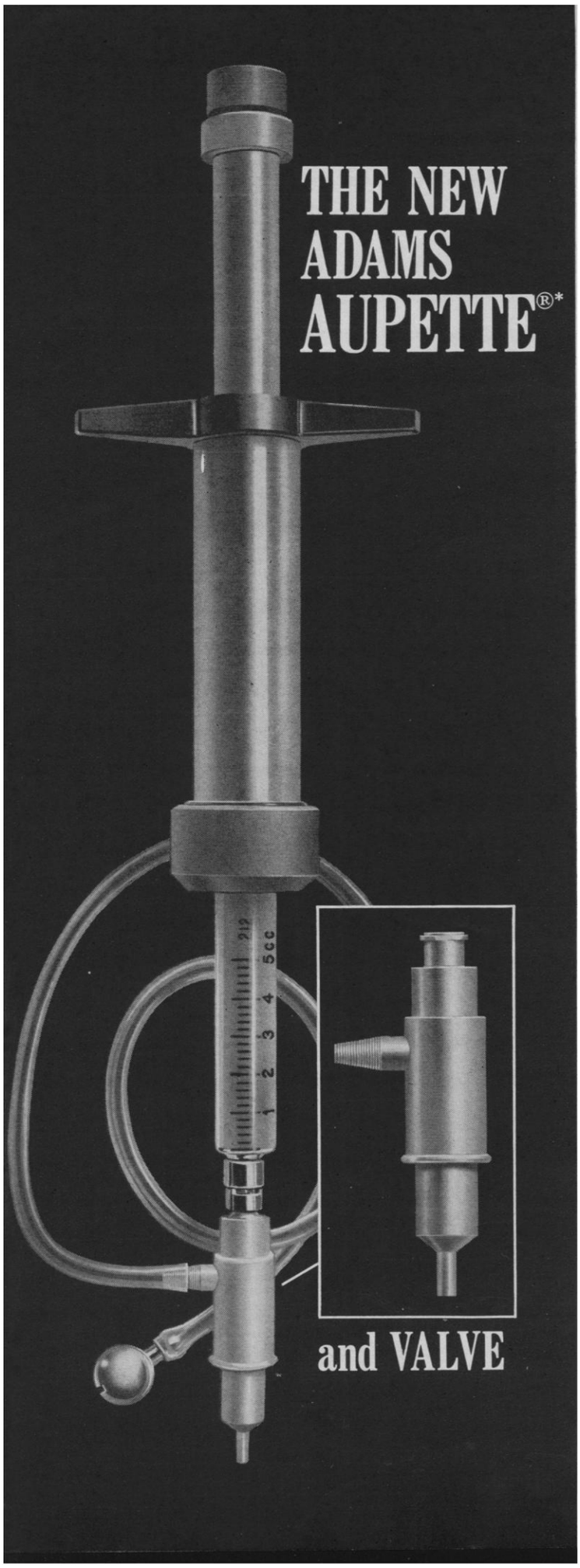
Commenting on the Daddario subcommittee's recommendation that the National Science Foundation take greater initiative in the determination of national science policy, Abelson (4 Feb., p. 521) says that "science policy cannot be made without reference to national goals," that these are established by politicians, and that "if politicians wish to have a sharper formulation of policy they must provide a more clear-cut description of the goals and of the relative priorities."

It is easy to confuse national plans with national goals.

National goals should arise in the consensus of the population, not in the mind of a politician. If later his speeches seek to articulate a public desire as a means to re-election, this is not the establishment by the politician of a national goal. For example, equality of opportunity is emerging as a national goal. So is a pollution-free environment. Such desires emerge slowly, are difficult to realize, and frequently entail heavy demands on the scientific community, however slow it may be to respond.

The defense industry has an attitude with legitimate roots which dictates passive waiting for government to state the requirements before the industry will open a major campaign. I sense this attitude in Abelson's characterization of scientists. And yet the scientific community should be able to identify and promote some worthy national goals with success at least comparable to that of the radio industry in foisting color television on the consuming public. In short, I don't view with alarm; I call for accepting responsibility.

Finally, Abelson says that because

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the national goal of winning the war was clear and persistent, "[scientific] accomplishments during the war were unprecedented, and they have not been matched since, in rate or quality." I wonder if they are not matched by—for example—the intercontinental ballistic missile, DNA, polio vaccine, the Rangers, Mariner IV, Early Bird, the jet transport, and all the other achievements our colleagues could add to the list.


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### Evolution of Hairlessness in Man

Most of the remarks made by Baker, Kraft, and Fentress (Letters, 25 Feb., p. 935) seem to me to be interesting extensions of various lines of thought suggested by my essay on "The ethical basis of science" (3 Dec., p. 1254). The unabridged essay contained in the book from which the article derived may offer other extensions and possibly clarification of some moot points.

I must take exception, however, to Baker's comment on my "rather Lamarckian statement connecting the 'loss of certain unnecessary structures, such as bodily hair, once clothing was invented.' " There is nothing whatever Lamarckian about the statement. It would be "Lamarckian" only if I had said or implied that the needs or desires of the human being had led to the inheritance of a trait. Natural selection is required to maintain every functioning, necessary feature at a functioning level. Whenever, by change of environment, a once useful structure becomes useless, the prevalent nature of mutation will lead progressively to its reduction or deterioration. That is to say, it is by *mutation in the absence of natural selection* that functionless structures become reduced, then vestigial, and finally disappear altogether. No geneticist or evolutionist to my knowledge would propose any Lamarckian explanation for the disappearance of useless structures. The wings of all the now wingless insects of Kerguelen have presumably been lost solely by natural selection in an environment where wings were not only useless but a positive handicap. Eyes in cave fish and salamanders are presumably no detriment, but they have lost significance and the animals have evolved to a blind or even eyeless condition.

The situation is similar with respect to human hair. All other primate species, whether living in the tropics or in temperate regions, whether arboreal or ground-dwelling, are hairy. Man, too, still possesses all his hair follicles, but the hair itself, over most of the body, is reduced and vestigial. In this respect he is comparable to the elephants or the cetaceans. Evolutionists suppose that the relative hairlessness of these mammals arose from a change in selection pressure, and it is reasonable to suppose the same is true of the human species. What was this change in selection pressure? One may postulate a positive advantage in being hairless, a disadvantage in hairiness; or one may postulate that hairiness simply became inconsequential to man. The first hypothesis does not seem very probable, because the human species, evolving in East Africa or wherever else, was in the company of other primates who did not become hairless, to judge from their modern descendants. Although the matter must of course remain without conclusive proof, it seems far more reasonable to suppose that man very early in his separate existence as a species (or genus) began wearing clothing (in the form of skins) and later using fire to warm himself. Thus he changed his environment sufficiently to make hairiness an inconsequential feature, except on the more exposed parts of his anatomy.

It is highly significant, as a support of this theory, that head hair, so clearly a protection from sun, wind, and rain, has been retained. Mutations eliminating only body hair have not been removed from the population by natural selection, while those that eliminate head hair have been extinguished. I would go so far as to propose seriously that baldness, like myopia, is largely a genetic trait that has only become widespread and common in human populations since man became relatively civilized and keen vision and a good head of hair were no longer so important to survival. In fact, baldness is still limited almost entirely to males who have passed the age at which most males, in primitive times, would have died of various causes. Thus the apparent extension of baldness as a common human trait is largely a matter of the extension of the life span. That cannot be the case for general body hairlessness.


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# Waste Management and Control

The committee on pollution of the National Academy of Sciences–National Research Council (*Science*, page 329) has produced an excellent report.* The document is readable, rich in fresh viewpoints. In its recommendations it outlines major problems and points to gaps in knowledge, but it does not promise that the problems of waste management will be solved if only enough money is poured into research and development. Rather, it deals with the matter broadly, emphasizing both the technical and the political aspects.

The document's readability is due in part to the level of presentation but even more to the insights it provides. "Pollutants are the residues of the things we make use of and throw away. . . . As the earth becomes more crowded there is no longer an 'away'. One person's trash basket is another's living space."

The report states our present waste disposal problem concisely: "Our whole economy is based on taking natural resources, converting them into things that are consumer products, selling them to the consumer, and then forgetting about them. But there are no *consumers*—only *users*. The user employs the product, sometimes changes it in form, but does not consume it—he just discards it. Discard creates residues that pollute at an increasing cost to the consumer and to his community."

The problems of waste management and control are numerous, complex, and more serious in some regions than in others. In urban areas they take three major forms—air pollution, water pollution, and disposal of solid wastes. The major contributors to air pollution are motor vehicles, including automobiles, and generators of electricity. In many metropolitan centers the level of pollutants is already high, and unless vigorous efforts are made, the levels will become even more dangerous.

Water pollution, already serious, is destined to get much worse. Even with efficient waste treatment, by 1980 our effluents would be sufficient to consume all the oxygen of all the dry-weather flow of the 22 river basins in the United States. A factor of growing importance is the thermal contribution of electrical power stations which use river water for cooling. A warm river cannot dissolve as much oxygen as a cool one; hence it becomes anaerobic more readily.

The production of solid wastes is now about 8 pounds per person per day, and it is increasing; there are more people, they use more things. In addition, there is less salvage. Many cities have exhausted their cheap sites for dumps and must haul refuse farther and farther away. The area required for sanitary landfill is about 1 acre per year per 10,000 population for each 10-foot layer of waste deposited. Unless policies change, the urban centers will become surrounded by mountains of waste.

In dealing with pollution problems, the technological ones are not the main ones. New public policies and institutional arrangements are needed before technological possibilities can be exploited. Political boundaries often do not correspond to watersheds, and air pollution moves across state lines. Many problems can be dealt with on a local or regional basis. However, the federal government should take more initiative, especially to stimulate research on pollution and the development of new instrumentation. It should encourage adequate collection and proper evaluation of data and should develop standards so that local authorities may obtain informed advice.

The problems of pollution and waste management are difficult and complex, but they will yield if the public demands action and if political authorities utilize effectively our scientific and technical capabilities.—PHILIP H. ABELSON

* "Waste Management and Control: A Report to the Federal Council for Science and Technology," *Nat. Acad. Sci.–Nat. Res. Council Publ. 1400* (1966).

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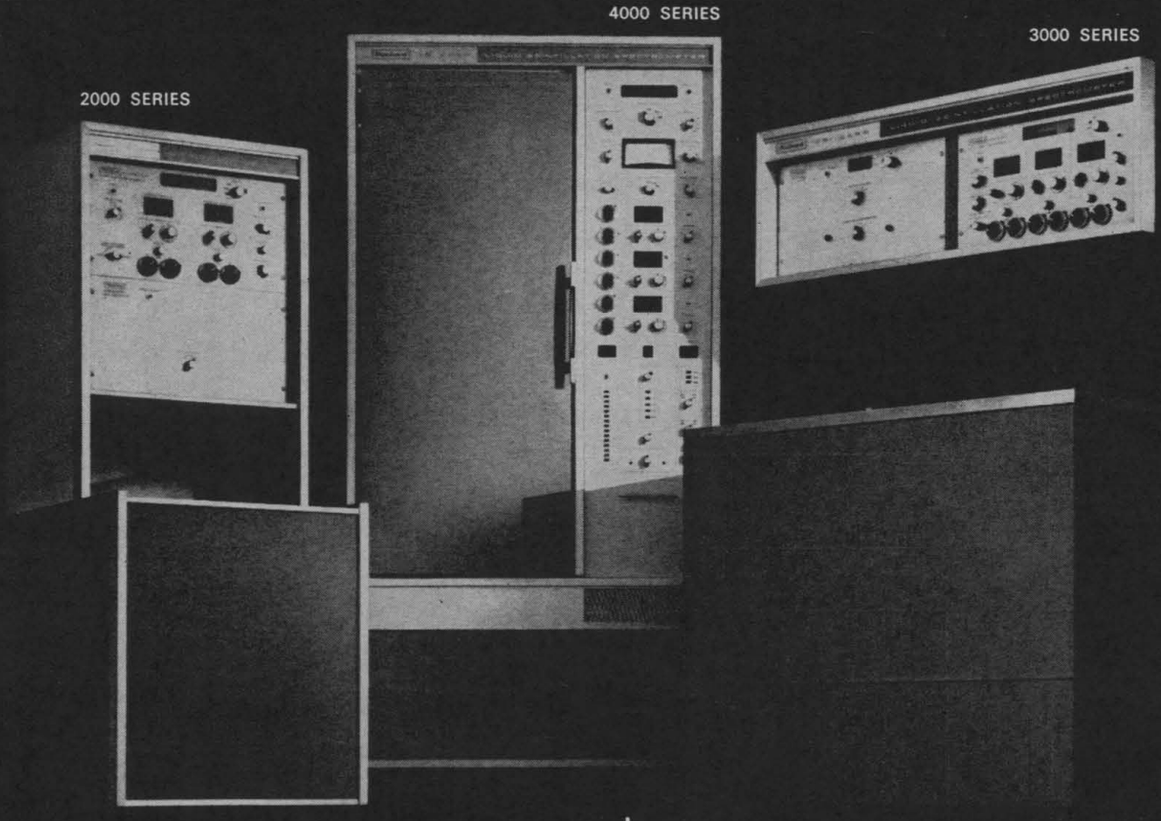


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nual, Gatlinburg, Tenn., and Great Smoky Mountain Natl. Park. (A. J. Sharp, Dept. of Botany, Univ. of Tennessee, Knoxville)

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*1–6.* **Electrochemical Soc.**, annual spring mtg., Cleveland, Ohio. (The Society, 30 E. 42 St., New York 10017)

*1–6.* International College of **Surgeons**, North American Federation, congr., Houston, Tex. (S. E. Henwood, 1516 Lake Shore Dr., Chicago, Ill. 60610)

*2–3.* Canadian **Aeronautics and Space** Inst., annual mtg., Ottawa, Ontario. (The Institute, 77 Metcalfe St., Ottawa 4)

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*3–5.* British Joint **Computer** Conf., Eastbourne, England. (Secretariat, Inst. of Electrical Engineers, Savoy Place, London W.C.2, England)

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*5–7.* Midwestern **Psychological** Assoc., Chicago, Ill. (F. A. Mote, Psychology Dept., Univ. of Wisconsin, Madison)

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*6–7.* Institute on **Lake Superior Geology/Mineralogical** Soc. of America/Soc. of **Economic Geologists**, mtg., Michigan Technological Univ., Saulte Ste. Marie. (A. K. Snelgrove, Michigan Technological Univ., Houghton 49931)

*6–7.* **North Carolina Acad.** of Science, Catawba College, Salisbury. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)