facilities into a zero-sum game. Although the provisions would go into effect only if science research is allocated more money than it gets now, the bill calls for diverting new funds the agencies could otherwise spend to increase research on campus.

Congressman Buddy MacKay, another Florida Democrat, gave some unsolicited advice to the NAS assembly. He urged them to make common cause with state officials, corporate executives and public-interest leaders. He cautioned that "if they see an irreversible move to the pork barrel, they are no longer your supporters"—rather, they will be competitors with superior skills when it comes to "reaching for the levers of power." MacKay addressed the squabble directly: "Unless we expand this nation's commitment to basic research," he said, "you are going to be at each other's throats."

Lest the audience not grasp MacKay's meaning, Fuqua, at another session, was more blunt. It would be folly, he said, if scientists and academics think the Federal government will provide "the kind of money you people are talking about. There's no way that's going to happen. We're in for some rough, rough times—at least until the end of this century."

Funding academic research facilities can be more complicated and controversial than appropriating money for a new weapons system, according to Fuqua. Large sums of money for academic research will be "hard to get," he said. "We've grown accustomed to success. The public wants to know when it's going to get something useful. A good deal of the public just doesn't understand basic research.... What you must do is look to alternative financing . . . in new investment strategies."

Among the ideas for financing new buildings and facilities:

▶ State bond issues, such as the $90-million issue that New Jersey voters approved in November 1984 for academic high-tech, was a concept advocated by Edward Bloustein, president of Rutgers University. The issue provided Rutgers with $38.2 million earmarked for laboratories to study ceramics, food technology, biotechnology and computer-aided production techniques. In addition to this, Rutgers, which can issue tax-exempt bonds, like most state universities, sold $17 million in general obligation bonds to supplement the state's funds. Interest and principal on the bonds will be paid back from overhead charges to Federal grants that would otherwise go to the state.

▶ An independent, nonprofit corporation that would be funded by Congress, with additional contributions from business, foundations and other investors, for the purpose of providing direct loans as well as credit supports

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and "leveraging" guarantees so that banks and other financial institutions can offer low-interest tax-exempt bonds to finance large academic projects. The idea comes from David C. Clapp, partner in the Goldman, Sachs investment house. In this concept the leveraging capability is similar to the Federal program of Urban Development Action Grants, which provides direct grants or low-interest loans, in combination with tax-exempt borrowing, for rehabilitating inner-city areas. Clapp's idea already meets requirements of the Internal Revenue Code pertaining to tax-exempt financing. But he foresees trouble ahead if the Reagan Administration's current tax-reform plan becomes law, thereby eliminating tax-exempt bonds for private educational and health-care institutions. Even so, Clapp argues, Congress could preserve the proposed corporation for academic facilities by enacting a special provision dealing with the matter.

▶ Variations of financial arrangements already practiced, such as linkages between university medical centers and pharmaceutical companies, consortia formed by an entire industry in cooperation with universities (as, say, the Semiconductor Research Cooperative in California's Silicon Valley), university participation in industrial parks, alliances between a single school and a single company or Federal agency (as, say, NASA's support of Caltech's Jet Propulsion Lab), and organizations of universities formed around a local or regional research center, or operating a large national facility.

Such concepts for improving the condition of the nation's academic research infrastructure have been argued at length for nearly two years by a White House Science Council panel headed jointly by David Packard, board chairman of Hewlett–Packard Co, and D. Allan Bromley of Yale. Although the panel's central issue is whether US universities are up to training enough talented scientists consistently and continuously for the foreseeable future, the study of the current health of academic science is also reviewing the problem of physical facilities. One of the key recommendations of the long-awaited Packard–Bromley report calls for faster write-off periods for campus R&D facilities. As it is now, universities charge the government 2% overhead on each contract for facilities, meaning that buildings and labs are written off in 50 years. The panel is reportedly seeking a 4% or 5% overhead, which would enable colleges and universities to pay off their facilities in 20 to 25 years—a period considered a more reasonable lifetime for research installations.

"It is in the national interest," Schmitt told the conference on facilities financing, "that the government provides the right climate for appropriate investment by the public and private sectors to meet our present and future demands for innovative talent and new knowledge."

—Irwin Goodwin

Upgrading academic research equipment: Search for solutions

The rapid obsolescence and deterioration of research instruments "threatens the quality of our academic science as well as the quality of education of new scientists and engineers," Richard A. Zdanis, vice-provost of Johns Hopkins University, told the House Science and Technology Committee on 5 September. This dour judgment did not startle committee members, who are sitting as a task force engaged in a two-year study of US science policy, with academic research facilities and equipment high on the list of issues. Zdanis's testimony confirmed previous accounts that something is very wrong with the nation's research infrastructure on campus (PHYSICS TODAY, August 1984, page 65).

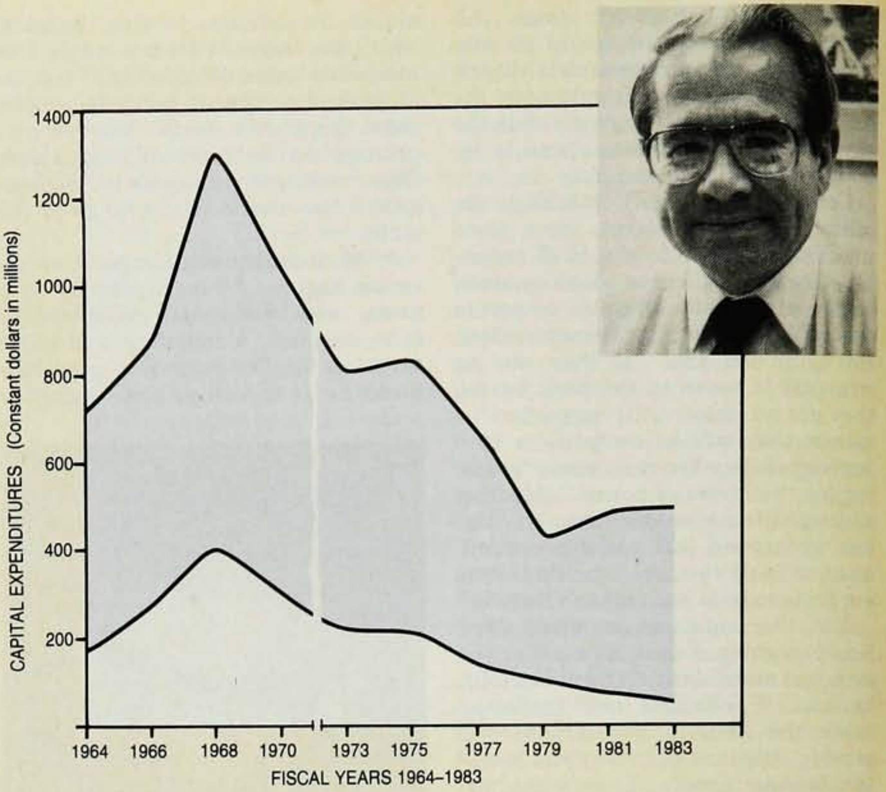
Representing Johns Hopkins, which, with $318 million for research from Federal sources in 1983, is in the top ten among some 600 colleges and universities that share $5 billion in government R&D funds, Zdanis seemingly has nothing to complain about. But as chairman of a steering committee that in August completed *Financing and Managing Our Research Universities*, a report based on a three-year study conducted under the auspices of the Association of American Universities, the National Association of State Universities and Land-Grant Colleges and the Council on Governmental Relations for the National Science Foundation, Zdanis knows the problem inside out.

The report is based on site visits to 13 private and public universities, including the Massachusetts Institute of Technology, Stanford University, the University of Illinois, Texas A&M and Duke University; such corporate labs as Beekman Instruments, Hewlett–Packard and Honeywell; and a few national labs, headed by Los Alamos and Sandia. In addition, more than 500 academic scientists and research administrators took part in a survey revealing that they consider at least 20% of their equipment to be outworn, outdated or outclassed.

Confirming NSF. In this conclusion and others, the report confirms the study of university research equipment done for NSF. The account of the NSF study, issued last June, indicates that 72% of the heads of science and engineering departments at 43 research universities indicated their professors and graduate students were prevented from performing "critical" experiments by the lack of sophisticated, contemporary equipment. The situation is even worse in the fields of computer research, materials science and physics, where 90% of the department heads reported that important studies have been thwarted by inadequate lab equipment.

The findings of the Zdanis study suggest that several interrelated factors cause the troubles. As scientific instruments have become more powerful and productive, their costs have exceeded the nation's inflation rate—advancing at one industrial lab by 16.4% per year between 1975 and 1981, while the consumer price index rose 9.9% per year. What's more, the pace of scientific progress has shortened the useful life of research instruments.

Instruments today are often superseded by more advanced models in five years or less. Equipment manufacturers have suceeded in devising novel instruments that now make possible many varieties of research that could not be done before in University laboratories. Universities can now obtain molecular-beam epitaxy systems (such as those used in making specialized semiconductor chips), infrared-absorption spectrometers, VAX-type scientific computers—but all at a high price. It is common for benchtop instruments to cost $50 000 or more. Research in some fields requires equipment that costs $100 000 to $1 million.



Spending on facilities and equipment for science research and instruction at universities by Federal and other sources has declined in constant dollars from its peak in 1968, according to NSF data, causing concern to a panel headed by Richard Zdanis (inset).

Funding of scientific equipment on campus has long been dominated by the Federal government, which paid for 54% of the research instrumentation in use during 1982–1983. The universities put up almost 32% of the cost of instruments and equipment, the states directly funded 5% and corporations, foundations and individuals contributed nearly 10%.

Improving pay. The academic building boom of the 1950s and early 1960s included outlays for instruments to outfit the labs. But once large capital investment ended, most universities, between 1966 and 1983, did not increase their budgets for instruments. Instead they preferred to improve the pay of teachers and researchers to keep up with steeply rising cost-of-living rates. The situation was made worse when Federal research agencies withdrew much of the capital support for obsolete and outworn academic equipment, from 1968 through the 1970s. In the 1980s, though, the agencies did much better. NSF raised its investments in instruments from 11% of its university R&D budget in 1978 to an estimated 17.5% in 1985. The Department of Defense launched a special five-year university instrumentation program in fiscal 1983, providing $30 million each year until 1987. The Department of Energy undertook a special $30-million program to upgrade scientific equipment for its academic researchers over a five-year period through 1988.

These programs were due primarily to the efforts of an interagency task force on university research instrumentation, organized in the first 100 days of the Reagan Administration by top officials at Defense, Energy, NSF and NASA, among others. Businessmen and academics who had been close to Reagan when he was governor of California and supported him for the Presidency could take some credit for getting across the message: Basic research, the linchpin in advancing industrial productivity and, hence, economic growth, needed more support, especially at universities. At his Senate confirmation hearing on 20 July 1981, George Keyworth II, then newly appointed as President Reagan's science adviser, described the deterioration of university laboratories and equipment as "disgraceful and deplorable." The magnitude of the equipment problem is underscored by DOD's experience. In 1983, the first year of its program, DOD received some 2500 proposals for instruments with a total value of $645 million. With its $30-million limit, DOD was able to fund only 200 proposals. In fiscal 1984, DOD got 1870 proposals for equipment worth a total of $370 million and made 452 awards to 147 schools before its $30 million ran out.

In the past few months, NSF, DOE and DOD have made awards totaling nearly $40 million to universities for modern scientific instruments. While NASA has no specific program to provide equipment for its academic researchers, the agency allocates about 10% of its university grants and contracts to instrumentation. In fiscal 1984, accordingly, NASA obligated about $22 million for equipment in academic space science. Following is a program sampler of the other agencies:

▶ NSF has made 203 awards from the 1348 proposals received in the first year of its College Science Instrumentation Program for predominantly undergraduate four-year colleges and universities. The awards, totaling about $5 million and requiring matching funds, went to 172 institutions in 40 states and Puerto Rico. Among the awards involving physics equipment: $23 500 for a lasers and electro-optics lab at Western Kentucky University; $29 840 for a solid-state and semiconductor-device lab at the University of North Carolina at Charlotte; $39 609 for computer-controlled instruments at Ohio's Denison University; $27 985 for a laser spectroscopy system at Vermont's Middlebury College and $27 482 for upgrading an experimental physics lab at the University of Tennessee at Chattanooga.

▶ DOE's Office of Energy Research received 160 applications for $4.9 million of scientific instruments and made awards to 22 universities for fiscal 1985. Among these: $216 470 to Columbia University for a low-divergence excimer laser and high-resolution excimer-pumped dye laser; $283 000 to Case Western Reserve University for a high-resolution electron microscope; and $240 000 to the University of Illinois at Urbana–Champaign for a high-power rotating anode x-ray system.

▶ DOD's University Research Instrumentation Program has made 652 awards totaling $90 million in the last three fiscal years through its Office of Naval Research, Air Force Office of Scientific Research and Army Research Office. Though 47 of the leading 50 research universities have received nearly 63% of DOD's instrumentation awards, nearly 13% went to colleges and universities that were not currently funded by the armed forces. Some of this year's winners: $300 000 to the University of Pittsburgh for an FPS-164 attached processor; $60 000 to the University of Southern California for an infrared absorption spectrometer for transmitting parity species; and $122 500 to Harvard University for a cw ring dye-laser system.

Few academics believe such programs can entirely overcome the deficiencies. As Zdanis informed the House committee, "The overall problem is so large . . . that it cannot be properly addressed without substantial, sustained investments by all sources—Federal and state governments, universities and the private sector. I would like to emphasize the words 'sustained investment.' Laboratories in most sciences must now be reequipped about every five years to remain competitive in research."

The 237-page report, *Financing and Managing University Research Equipment*, carries numerous recommendations for all. It makes the point that such beleaguered regulations as Office of Management and Budget Circulars A-21 and A-110 and the Federal Acquisition Regulations do not contribute to the problem, but that inconsistent interpretations by agency officials often complicate the purchase, management and use of academic research equipment. As a first step the Zdanis report urges top Federal officials to play up the importance of research under their agency's auspices through policy directives and personal assurances. Before the nation and its universities can attain the scientific and economic goals set out by them, Zdanis told the House members, the agencies must make plain their commitment to academic research, including the efficient acquisition and management of research equipment.

Covering costs. To this end, the report asks Washington to reckon the full costs of buying, operating and maintaining the equipment, which may include funding the full expense of renovating space and installing and servicing research apparatus through regular research-grant procedures. These costs should be covered explicitly, says the report, either by the research grant or contract, or as a condition for making the award. The report goes on to suggest that the agencies adopt procedures for spreading the cost of expensive equipment charged directly to project awards over several years and allow the cost and use to be shared across award and agency lines. It proposes that OMB modify its application of Circular A-21 so that interest payments are considered allowable costs by all agencies.

The report further recommends that states grant public universities and colleges greater flexibility in handling funds, including permission to carry funds forward from one fiscal period to another. Another recommendation sure to evoke outcries of special pleading calls for the states to "examine the use of their taxing powers to foster academic research and modernization of research equipment."

For universities, the report advocates that they "favor research and equipment" in planning how to allocate their money. Moreover, they need to budget realistically for operating and maintaining research equipment, which means including the costs of space renovation, service contracts, technical support and electric power. It also suggests that universities "seek better ways to facilitate the transfer of research equipment from investigators or laboratories that no longer use it to those that could use it."

The report also recommends that universities explore the greater use of debt financing and leasing as ways of acquiring research instruments. It proposes that industry make more use of the Economic Recovery Tax Act of 1981 (ERTA) to donate research equipment to universities and to fund academic research. It calls on Congress to revise ERTA so that it covers computer software, spare parts and service contracts that are not part of original donations and make the R&D tax credit permanent. —Irwin Goodwin

NSF idea: Materials research groups

Among the research programs funded by the Federal agencies, materials science is considered by government officials to be one of the most exciting growth fields. Materials research ranges from improving alloys and ceramics to fundamental studies of the structure and properties of materials on the atomic scale and the universal principles of phase transitions. As such, the field contributes importantly to US economic competitiveness by providing scientific underpinnings for new technologies, increasing productive efficiency and contributing to better products that may possess greater strength, longer durability, corrosion resistance and special electrical characteristics. It also pays off from time to time in new energy and defense technologies.

Accordingly, the Department of Energy plugs into the field about $135 million annually, making it the largest single source of support for materials research in the US. The Defense Department is arming materials studies by $88 million during fiscal 1985 in budget category 6.1 (for basic science) alone. NASA's program for materials processing in space is expected to soar from $27 million this fiscal year to $34 million in fiscal 1986 as part of its "seed money" to attract commercial investment in space manufacturing. The National Science Foundation is spending some $107 million this year on materials research, with the Mate-