Radio Astronomy: NSF Scrutinizing Proposals for Six Major Instruments

In their quest for funds to build a new generation of costly research instruments, American radio astronomers are now passing through a process of scrutiny and competition that may well become typical for all expensive branches of science.

Under various auspices, the astronomers have submitted to the National Science Foundation (NSF) six separate proposals for major new radio and radar instruments—with a total cost of at least $130 million.

Both NSF and the astronomers know that getting the money—even though it would be spent over 5 or more years—will not be easy. So the projects are being screened with exceptional care, not only to minimize the strain on NSF's traditionally tight budget, but also to develop as compelling a scientific and political case as possible.

The effort to get at least some of the six projects started soon adds up to a significant test of the growth potential of government support for basic research at a time when the administration is feeling severe pressure to restrict rather than expand domestic spending.

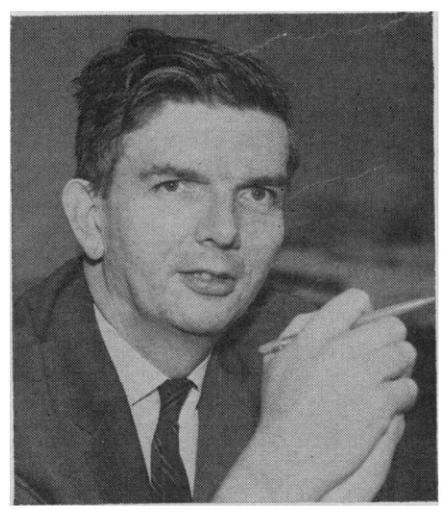
In the main, the astronomers have followed the recommendations produced in 1964 by a panel of the National Academy of Sciences, headed by A. E. Whitford of the Lick Observatory. But the estimated costs of the major projects have about doubled, from $66 million in the Whitford report to more than $130 million. (*Science*, 25 December 1964 and 13 November 1964)

The six projects now under consideration by NSF are as follows:

1) The National Radio Astronomy Observatory (NRAO) of Green Bank, West Virginia, has designed the so-called Very Large Array (VLA), the estimated cost being $52 million. The VLA would consist of 36 dishes, each 25 meters, distributed along three arms of a "Y." The arms, which would be railroad tracks for movement of the dishes, would be 21 kilometers long. The NRAO is run under an NSF contract by Associated Universities, Incorporated, whose member universities are Columbia, Cornell, Harvard, Johns Hopkins, M.I.T., Pennsylvania, Princeton, Rochester, and Yale.

2) The newly formed Northeast Radio Observatory Corporation (NEROC), which succeeds the Cambridge Radio Observatory Committee, has proposed that a 135-meter fully steerable dish antenna be placed under a plastic, steel-ribbed radome.

The estimated cost of the NEROC project would be $27.8 million, including $9.6 million for the antenna itself, $8.1 million for the radome, $3.5 million for advanced radar equipment, and $1.7 million for auxiliary movable antennas that would be used for interferometry. The members of the original Cambridge Committee were M.I.T. and its Lincoln Laboratory, Harvard, and the Smithsonian Astrophysical Observatory. On 6 July, the Cambridge group evolved into NEROC with the addition of Boston University, Brandeis, Brown, Dartmouth, University of Massachusetts, University of New Hampshire, State University of New York at Buffalo and Stony Brook, Brooklyn Polytechnic Institute, and Yale. NEROC plans to put its telescope at a site in New England. Widened membership gives NEROC a New York political base, as well as a New England one, and added strength from state universities. NEROC's membership overlaps with NRAO. Harvard, M.I.T., and Yale belong to both groups.



Robert H. Dicke

3) A 100-meter fully steerable paraboloid to be placed at the Owens Valley Observatory, which is operated by California Institute of Technology.

As with the NEROC proposal, a special corporation has been formed to administer the western project. It is called Associates for Radio Astronomy (ARA). Besides Caltech, the members of ARA are Stanford, the University of California, and the University of Michigan. ARA estimates the cost of its project at $17.8 million.

4) Caltech, a member of the ARA, has made a separate proposal to add seven dishes to one already in existence at Caltech's Owens Valley Observatory at a cost of about $15 million.

5) An improvement in the accuracy of the surface of the 300-meter Arecibo telescope is proposed so that it would be useful down to wavelengths of 10 centimeters. Presently, the Arecibo dish works best at a frequency of 440 megacycles. The Arecibo project is administered by Cornell University, which has a joint program with the University of Sydney in Australia. Estimates for the resurfacing have hovered around $3 million, but some observers feel this figure is far too low.

6) A device is to be used for study of the upper atmosphere and ionosphere, proposed by the Committee on Institutional Cooperation of the University of Chicago and the midwestern "Big Ten" universities. The estimated cost is $12 million.

The committee has been studying the possibilities of a 100-meter dish which would be open to elements or of an enclosed 120-meter radar instrument.

Accompanying the financial pressures are many technical uncertainties. For example, the NEROC proposal for a radome-enclosed 135-meter antenna raises the question of a radome's suitability for radio and radar astronomy. Critics of the radome idea maintain that the steel ribs of the radome cut off too much of the dish surface. Proponents of the idea assert that a

dish which is protected by wind and temperature variation can be maintained at a given accuracy at a fraction of the cost of a freestanding instrument.

The NEROC backers cite a large number of theoretical and practical experiments on the interference from the ribs of a radome and also on the method of erecting a 156-meter-high structure to enclose a 135-meter dish.

When Sir Bernard Lovell, director of the Jodrell Bank Observatory, visited NEROC in May, the staff argued the merits of a radome so forcefully that Sir Bernard, who has over $11 million allocated toward a 120-meter dish at his observatory, promptly dispatched a five-man team to Cambridge, Massachusetts, to look at the details.

Then there is the element of competition among the six designs. The NEROC telescope can be regarded as a direct competitor with the ARA west-midwest proposal. The proposals for the Very Large Array of the NRAO (to be placed in the southwest) and the array of 40-meter dishes in Owens Valley are also in competition.

However, the midwestern backers of the radar dish to study upper atmosphere and ionosphere problems have sought to avoid direct competition with the other proposals. The midwest astronomers sent their proposals to the atmospheric sciences section of NSF's division of environmental sciences, while the other proposals went to the astronomy division of mathematical and physical sciences at NSF.

To evaluate the six proposals, NSF supplemented its standing advisory apparatus by establishing, in June, a special panel under the chairmanship of Robert H. Dicke, a Princeton University physicist heavily involved in both theoretical and experimental astronomy.

The other members of the panel are: Bart J. Bok of the University of Arizona, William W. Morgan of the Yerkes Observatory, Eugene N. Parker of the University of Chicago, Sterling Colgate of the New Mexico Institute of Mining and Technology, Rudolph Kompfner of Bell Telephone Laboratories in Holmdel, N.J., Merle A. Tuve of the Carnegie Institution of Washington, and Gart Westerhout of the University of Maryland.

Three of the panel members are identified with optical astronomy: Bok, Morgan, and Parker. To represent the theoretical problems of plasma physics

NEWS IN BRIEF

● **"BRAIN DRAIN"**: The number of scientists, engineers, and physicians immigrating to the United States increased 77 percent between 1956 and 1966, according to a report by the House Research and Technical Programs Subcommittee. Representative Henry S. Reuss (D–Wis.), chairman of the subcommittee, stated, "According to this study, a growing scientific brain drain from the developing countries may be working at cross purposes with our foreign aid program." The report notes that immigrant scientific manpower in 1966 provided nearly 10 percent of the additions to the U.S. supply of engineers, and 26 percent of the new physicians. Between 1956 and 1966, the developing countries' share of scientific immigrants rose from 33 to 46 percent of the total. These countries were the source of 4390 scientific immigrants in 1966. During the same year about 6000 students from developing countries were graduated from U.S. colleges and universities, giving the countries a net gain in scientific manpower of three in ten new graduates. Of the 1966 scientific immigrants, 60 percent were from the 13 nations receiving the bulk of U.S. aid: Brazil, Chile, Nationalist China, Colombia, the Dominican Republic, India, Iran, Israel, Korea, Pakistan, the Philippines, Turkey, and Vietnam. The report also indicates that foreign-born scientists and engineers are more likely to be engaged in research and development work than their American counterparts. The study, *The Brain Drain into the United States of Scientists, Engineers, and Physicians,* can be obtained without charge from the Research and Technical Programs Subcommittee, House of Representatives, Washington, D.C.

● **NEW ACADEMIC PROGRAMS**: The University of California, Berkeley, has established a Department of Demography, chaired by Judith Blake Davis who previously headed the Group in Demography. At the University of Illinois in Urbana, the National Laboratory on Early Childhood Education has been started. The laboratory will attempt to coordinate the work of six educational research and development centers, located at the University of Arizona, Tucson; University of Chicago; Cornell University, Ithaca, N.Y.; George Peabody College, Nashville, Tenn.; New York University, New York City; and Syracuse University. The laboratory and centers are all funded by the U.S. Office of Education. J. McVicker Hunt will head the coordination activities at the new laboratory in Urbana.

● **DEFOLIANTS**: Defense Department procurement of defoliant chemicals for use in Vietnam is proceeding at a steady pace. The Pentagon recently announced contracts of $57.7 million to eight companies for the chemical agents. Actual yearly expenditures rose from $12.5 million in fiscal year 1966 to $45.2 million in fiscal 1967. Estimated expenditure for fiscal 1968 is $43.3 million. The companies supplying the defoliants are Dow Chemical, Diamond Alkali, Uniroyal Chemical, Thompson Chemical, Hercules, Monsanto, Ansul, and Thompson Hayward.

● **R&D RESOURCES**: U.S. research and development expenditures are projected at $25 billion in 1968, up by $1 billion from 1967, according to an NSF report. The report notes the continuing upward swing of R&D expenditures compared with $22.2 billion in 1966 and $20.5 billion in 1965. However, the average annual growth rate of 6.9 percent for the 1965–68 projection is down from the 9.5 percent increase amassed over the preceding 7 years. The greatest period of growth for R&D expenditures was between 1958–65, when they rose 15.8 percent. According to the report, "Outlays for research account for 35 percent of the R&D total; expenditures for development amount to 64 percent." Expenditures for R&D rose more rapidly than the gross national product and R&D manpower also grew faster than the civilian U.S. labor force during the period studied. Between 1953–65, expenditures rose at an annual rate of 12.1 percent compared with 5.1 percent for the gross national product. R&D manpower advanced from 237,000 full-time equivalent employes in 1954 to 504,000 in 1965, an annual average increase of 7.1 percent compared with 1.5 percent for the national labor force. The report, *National Patterns of R&D Resources, 1953–68—Funds and Manpower in the United States,* is available from the Government Printing Office, Washington, D.C., for 30 cents.

was Colgate's function. Kompfner is an expert in electronics, and Tuve is a pioneer in ionospheric studies. The only radio astronomer on the panel is Westerhout. Dicke himself is well known for the invention of a radiometer widely used in radio astronomy, most notably in recent studies of the so-called "fireball radiation."

One of Dicke's first steps, while he was out of reach on a Canadian vacation, was to direct the backers of each of the six projects to boil their cases down to five pages; this was no easy task, since many years and substantial sums had gone into the preparation of these proposals.

Then the panel assembled in Washington for an unusual set of hearings, which began 24 July and ran for 4 days. It was clear that the hearings, as well as the agonizing effort of boiling down complex cases into five pages, were intended as a kind of forcing house for American radio astronomy.

The representatives of each project were allotted half a day to explain their projects, after an opening day of explanatory statements by project leaders and by representatives of U.S. government agencies involved in radio astronomy.

The representatives were not heard in isolation. The men from the other projects were around throughout the presentation of their rivals' cases.

There was the opportunity for cross-examination, although the novelty of the procedure and the large issues involved are reported to have inhibited much sharp byplay.

After each day's meeting, the Dicke panel met in executive session. On 28 July, there was a full day of executive session, and then the panel agreed on its recommendations to NSF Director Leland J. Haworth.

More than the imminent autumn budgetary struggle within the Executive Branch lay behind the Dicke panel's speed. Most astronomers on the panel and in the six projects plan to be in Prague at the end of August for the triennial meeting of the International Astronomical Union.

With their colleagues from all over the world, the American radio astronomers could hardly have kept silent about the results of one of the most significant attempts yet made to fix priorities in a major field of science.

—VICTOR K. MCELHENY

Technology and the Environment: A New Concern on Capitol Hill

The list of afflictions man and his environment suffer from modern technology is long. Smog-filled skies, polluted rivers, noisy streets jammed with traffic, and dehumanized conditions of urban life that help promote riots—these are only a few of the most familiar. In Washington, Congress and the Executive Branch have been groping for means to cope with such problems. Laws and programs are enacted to stop pollution, untangle traffic, and rebuild downtowns. But by reacting to crises, instead of anticipating and avoiding them, the government has fallen behind in a difficult game.

A chief cause of this failure of foresight, many would agree, is that government and society generally have not taken an overall view of technology and its impact on the environment. It is this diagnosis that underlies current efforts in the Senate and House to have Congress take a more searching look and strengthen its powers of prophecy and control. The most advanced efforts of this kind are those led by Senator Edmund S. Muskie of Maine and Representative Emilio Q. Daddario of Connecticut.

Muskie has aroused the sympathetic interest of some leading scientists both in and out of government by proposing that the Senate establish a temporary Select Committee on Technology and the Human Environment. An "insider" to the Senate establishment, Muskie may be well justified in believing that the Senate will act favorably on his proposal before the fall adjournment. Its chances of receiving bipartisan support seem good, for Senator Howard H. Baker, Jr., Republican of Tennessee and son-in-law of Minority Leader Everett M. Dirksen, is a keenly interested cosponsor.

The case for setting up the committee was developed in hearings held in the early spring by Muskie's Subcommittee on Intergovernmental Relations. The select committee—its 18 members drawn from six regular legislative committees (such as Interior, Public Works, and Agriculture)—would focus on the problem of how technological advance can be made more compatible with human needs and desires. Over a 3-year period it would hold hearings, conduct studies, and report on its findings. The result, Muskie believes, would be to illuminate a wide array of problems and possibilities which the legislative committees have neither the time nor the mandate to explore.

Daddario's plans are, at this point, less well-formed than Muskie's, but they aim in the same general direction. As chairman of the Subcommittee on Science, Research, and Development, Daddario is taking the first step toward establishing a program of "technology assessment." In March, the congressman introduced legislation to set up an independent board to help Congress identify potential technological advances and problems. He has since concluded, however, that the technology-assessment concept should be refined through a long-range study before a mechanism is proposed to carry it out.

Accordingly, in July Daddario said his subcommittee would undertake a three-phase program—hold hearings and seminars; initiate studies to be conducted by the Library of Congress' Science Policy Research Division; and explore the possibility of having the National Academy of Sciences and the National Academy of Engineering arrange for some technology-assessment projects to be carried out on a pilot basis.

The general view of the scientists who testified before the Muskie subcommittee was that the answer to problems resulting from the impact of technology on the environment is more